(Established 1832.)
AMERICAN ENGINEER AND RAILROAD JOURNAL.
NOVEMBER, 1906.

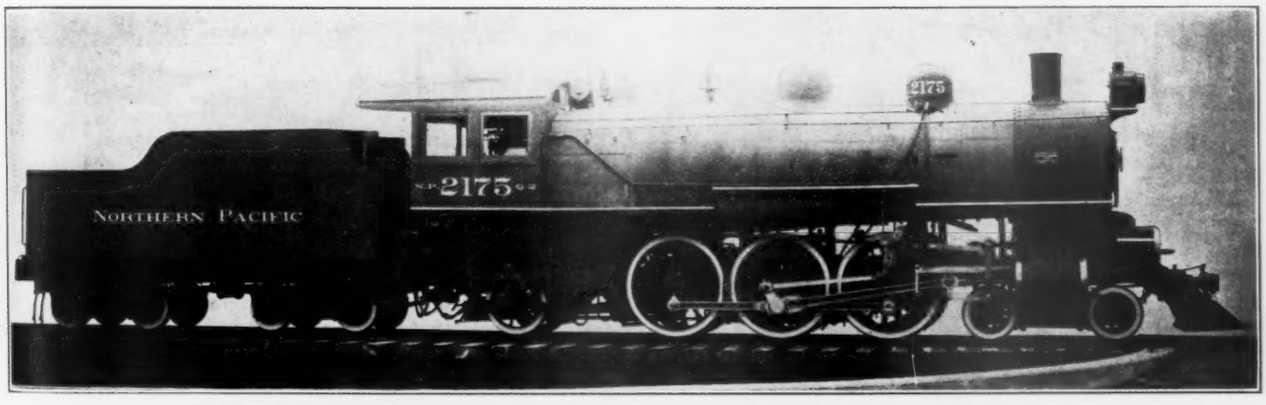
COLE FOUR-CYLINDER BALANCED COMPOUND PACIFIC TYPE LOCOMOTIVE.

NORTHERN PACIFIC RAILWAY.

40,000th of the American Locomotive Company.

On November 2d, the American Locomotive Company invited a party of guests to visit its Schenectady Works for the purpose of inspecting two very large and powerful Pacific type locomotives just completed for the Northern Pacific Railway Company. These two engines complete the total number of locomotives built by all of the works of this company to 40,000 and this method was taken of celebrating the event.

The locomotives are of the Cole balanced compound design and are the first of the Pacific type to be built with this arrangement of cylinders, all previous Cole compounds having been of the Atlantic type. They have the further distinction of being the heaviest of the type ever built, weighing 240,000 lbs. total with 157,000 lbs. on drivers. Other noticeable features embodied in the design are the use of the combustion chamber, of the same arrangement as was applied to the large order of 70 locomotives illustrated in the previous issue of this journal, and the use of the Walschaert valve gear.



COLE FOUR-CYLINDER BALANCED COMPOUND PACIFIC TYPE LOCOMOTIVE, NORTHERN PACIFIC RY.

The table on page 414 permits a comparison to be made between these leaders of their type and others of the balanced compound Pacific type previously built, as well as several different Cole compounds of the Atlantic type. Reference can be made to the article mentioned above (Oct., 1906, p. 395), for a comparison with the other Pacific type locomotives now owned by the Northern Pacific Railway Company, this one making the fourth arrangement of practically the same size and weight, giving this company Pacific type locomotives as follows: Simple engines without combustion chamber or superheater; simple engines with combustion chamber and without superheater; simple engines with combustion chamber and superheater, and balanced compound engines with combustion chamber and without superheater. This offers an exceptional chance for developing the advantages or disadvantages of these several features by direct comparison while operating under identical conditions.

In examining the table of comparative dimensions given, herewith, it should be remembered that the introduction of the combustion chamber largely reduces the actual total square feet of heating surface, and hence all ratios based on that figure. In these ratios the square feet of heating surface is used as an indication of boiler capacity, and reference should be made to the comments on the advisability of using a combustion chamber, given on page 393 of our October issue, where it is stated that one year's experience had indicated that there was no reduction in boiler capacity in spite of the large reduction of actual total heating surface, hence proper consideration of this feature should be given in comparing these locomotives with others not so arranged.

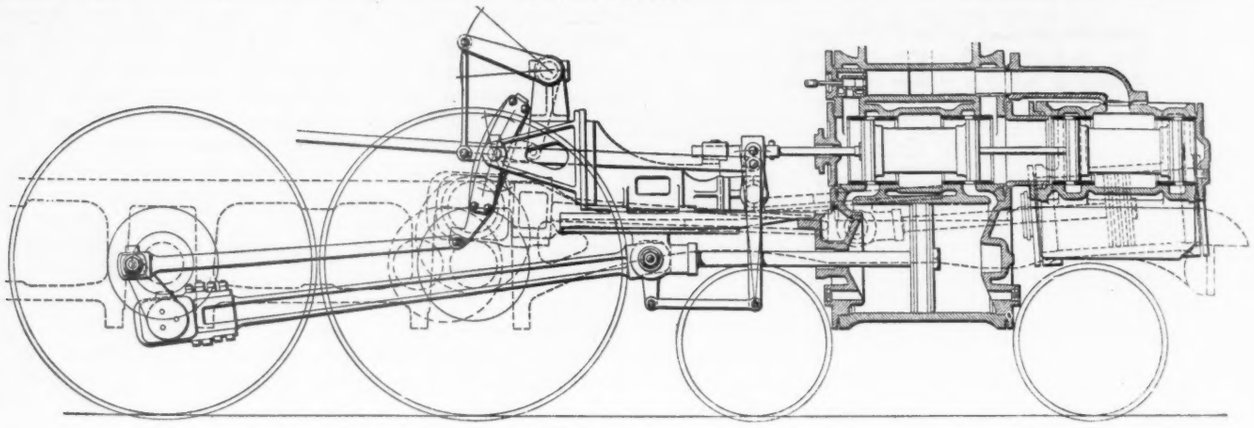
The illustrations show all the more important details very clearly and a careful examination of them will give a good idea of the prominent features of this interesting design.

The illustration showing the boiler has not been included as the boiler on this locomotive is practically identical with the one used on the previous Pacific type engines, the details of which were shown on page 394 of the October issue. The only change made has been in placing the cylinders 13 ins. farther ahead, making them 32 ft. 11 ins. from the front edge of the mud ring and 43 ins. ahead of the flue sheet. The front barrel sheet has been increased in length to make up this difference. In other respects the boilers are identical, and reference can be made to the previous article for a description of and comment on the design.

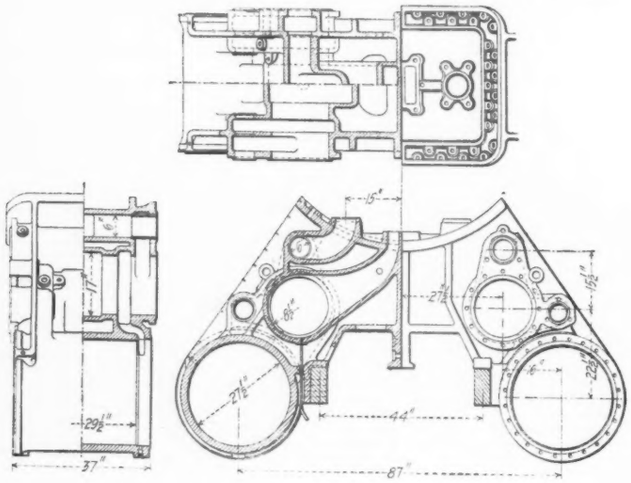
The Cole system of compounding is similar to the older DeGlehn arrangement in that it places one pair of cylinders, which in this case are the high pressure ones, between the frames and ahead of the other pair, connecting them to the front cranked axle, while the outside pair are connected to the second pair of drivers in the usual manner. It differs from that design, however, in having but one system of valve motion, which operates two piston valves one for each cylinder through one valve stem.

The design was first brought to public notice in 1904, when an Atlantic type locomotive with the Cole system of compounding was built by the American Locomotive Company for the New York Central and Hudson River R. R., and exhibited at the St. Louis exposition where it was tested on the Pennsylvania Railroad's locomotive testing plant. It made an exceptionally good record, and was the only locomotive tested which was able to maintain 75 miles per hour for one full hour. Its operation was most satisfactory from all points of view, and the results obtained showed the design to be excellent in all respects. Reference can be made to the report of these tests published by the Pennsylvania Railroad Company for the record given by this locomotive. Since that time this design has been specified by two other companies for Atlantic type locomotives. Descriptions of these engines were published in this journal in 1905, page 287, and 1906, page 73, and for the New York Central locomotive, 1904, pages 166 and 241.

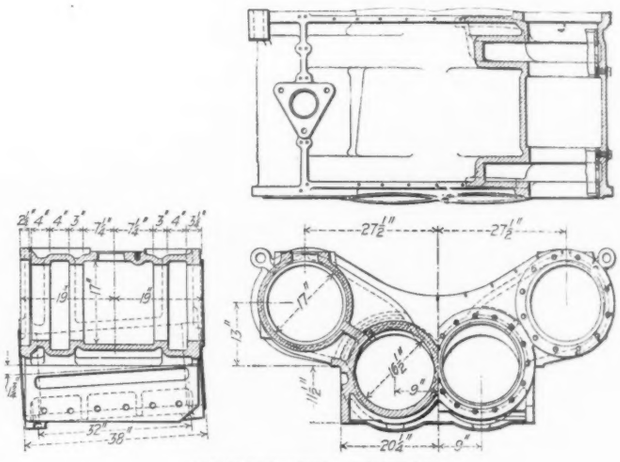
In brief, the cylinders in this design consist of a pair of low pressure, which was cast with a saddle and valve chambers, and are connected to the frames and boiler in a manner very similar to a simple engine and a pair of high pressure cylinders which are between the frames and drive on a crank axle and are in a separate casting fastened to the frames and saddle ahead of the low-pressure cylinders. The guides for the high-pressure cylinders are located beneath the low-pressure saddle. A passage is arranged for conveying steam



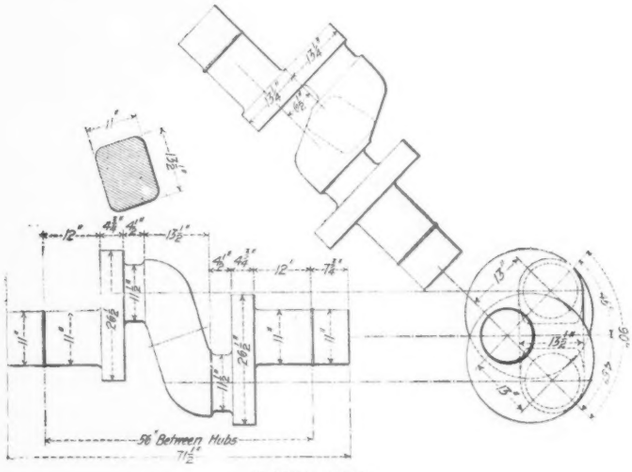
ELEVATION OF VALVES AND VALVE GEAR.



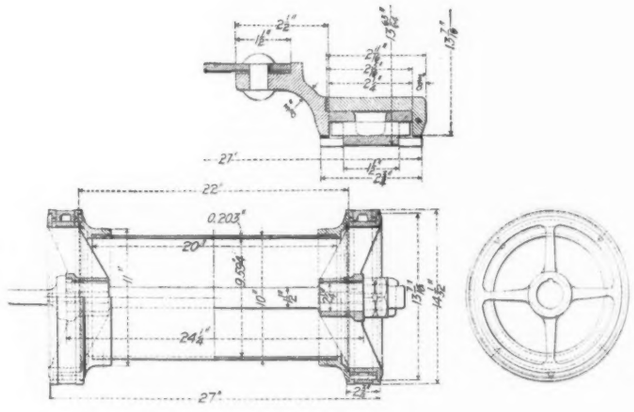
LOW-PRESSURE CYLINDERS.



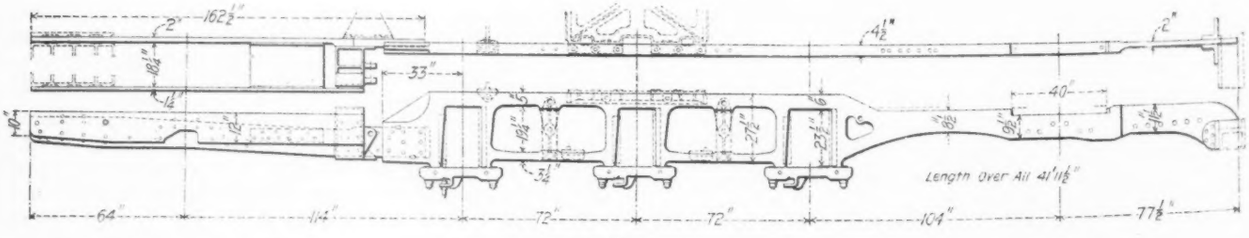
HIGH-PRESSURE CYLINDERS.



CRANK AXLE.

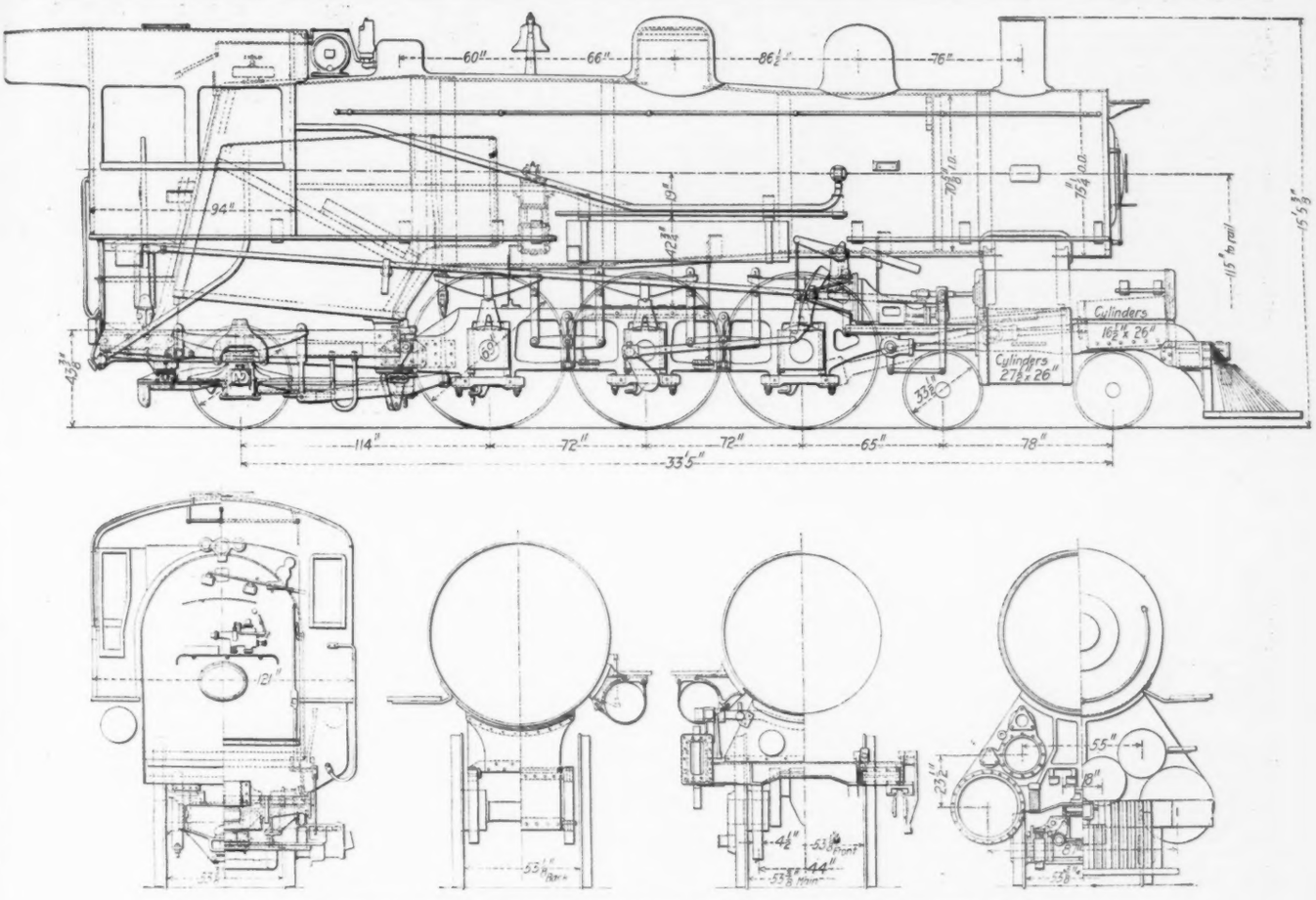


PISTON VALVE.



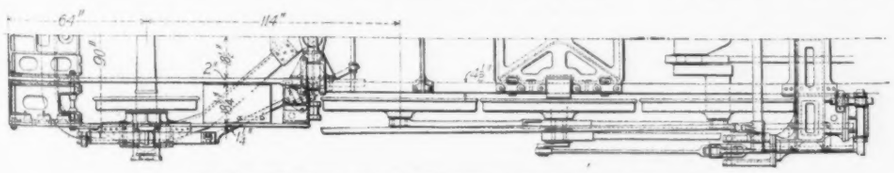
FRAMES.

DETAILS OF COLE FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVE, NORTHERN PACIFIC RAILWAY.



ELEVATION AND SECTIONS OF FOUR-CYLINDER BALANCED COMPOUND LOCOMOTIVE, NORTHERN PACIFIC RAILWAY.

from the saddle to the high pressure valve chamber through an elbow pipe heavily lagged and connecting through ground joints. An examination of the drawings of the cylinders will illustrate the details. A difference is noticed in this latest design over that used formerly, in that the high pressure cylinders are somewhat raised and slightly inclined. This is done, of course, for clearance of the front truck since connecting to 69 in. wheels, in a direct line, would throw the high pressure cylinder too low for the proper clearance. All previous Cole compounds have had wheels of 78 in. or more in diameter, and hence it was not necessary to incline the cylinders. The valve chamber is in a horizontal line, being a continuation of the low pressure chamber. Two 14-inch



PLAN SHOWING FRAME BRACING AND TRAILER TRUCK.

hollow piston valves are used, the one for the high pressure being arranged for inside admission, while the low pressure is outside admission and central exhaust. A starting valve is provided which will allow live steam at a reduced pressure to be admitted to the low pressure cylinder when desired. Both valves are connected to the same stem and have, of course, simultaneous movement. This stem is driven from a simple arrangement of Walschaert valve gear, the construction of which is clearly shown in one of the illustrations. There is, in this case, but one reverse shaft, the reach rod extending directly from the reverse lever to the end of a downwardly extending arm of this shaft, which is carried in bearings supported from the guide yoke, and is offset in the center to clear the shell of the boiler. The guide yoke itself is a large and stiff, although very light, steel casting spanning the frames and supporting the back end of the low pressure guides and all parts of the valve gear.

The frames, which are shown in one of the illustrations, are in two sections, the trailer frames being of a double plate design with the wheel between and connect to the main frames just back of the third driver, at which point there is a cross frame stiffening casting, to which the pivot of the radial truck trailer frame is connected, and which also includes the boiler bearings. The main frames are of the bar type 4½ ins. wide and 6 ins. deep over pedestals and 5 ins. deep at the top rail in other places. The depth is increased to 8½ ins. between the front pedestal and low pressure cylinder connection, and is narrowed to 2 ins. in width and 11½ ins. in depth where the high pressure cylinders are connected. An exceedingly broad steel casting is placed across between the top rails just above the pedestal of the second pair of drivers. This is a light but very stiff casting, and ties and stiffens the frames securely at this point. The special design of cast steel pedestal binder will be noticed in the illustration.

The illustration shows the crank axle which is on the forward pair of drivers and is of a solid forged design. The center portion, which includes the high pressure main rod journals, is connected to the wheel fit and driving journal portions by two circular sections 4¾ ins. thick. The high pressure journals are 4½ ins. wide by 11½ ins. in diameter, and the inclined part between them is rectangular in section 11 by 13½ ins. The cranks are arranged at 90 degs. between the two high pressure and 180 degs. between the high and low pressure on the same side of the locomotive. The trailer truck is of the radial roller-bearing design, which has been success-

Owner	N. P.	O., R. & N.	A., T. & S. F.	N. P.	Erie.	P. R. R.	N. Y. C.
Type of compound	Cole.	Baldwin.	Baldwin.	Simple.	Cole.	Cole.	Cole.
Wheel arrangement	4—6—2	4—6—2	4—6—2	4—6—2	4—4—2	4—4—2	4—4—2
Total weight	240,000 lbs.	231,300 lbs.	226,700 lbs.	223,000 lbs.	206,000 lbs.	200,500 lbs.	200,000 lbs.
Weight on drivers	157,000 lbs.	143,600 lbs.	151,900 lbs.	146,300 lbs.	115,000 lbs.	117,200 lbs.	110,000 lbs.
Size of cylinders	16½&27½ x26 in.	17&28x28 in.	17&28x28 in.	22x26 in.	15½&26 x26 in.	16&27x26 in.	15½&26 x26 in.
Diameter of drivers	69 in.	77 in.	73 in.	69 in.	78 in.	80 in.	79 in.
Steam pressure	220 lbs.	200 lbs.	220 lbs.	200 lbs.	220 lbs.	205 lbs.	220 lbs.
Tractive effort comp.	30,340 lbs.	28,300 lbs.	32,800 lbs.	31,000 lbs.	23,860 lbs.	23,300 lbs.	24,000 lbs.
Total heating surface	2,908 sq. ft.	3,055 sq. ft.	3,595 sq. ft.	2,978.4 sq ft.	3,634.7 sq. ft.	2,861.6 sq. ft.	3,465 sq. ft.
Firebox heating surface	241.8 sq. ft.	179 sq. ft.	192.8 sq. ft.	241.7 sq. ft.	181.1 sq. ft.	181.4 sq. ft.	198 sq. ft.
Length of tubes	16 ft. 9 in.	20 ft.	20 ft.	16 ft. 9 in.	17 ft.	16 ft. 3 in.	16 ft.
Grate area	43.5 sq. ft.	49.5 sq. ft.	53 sq. ft.	43.5 sq. ft.	56.5 sq. ft.	55.5 sq. ft.	50.23 sq. ft.
Weight on drivers ÷ tractive effort	5.18	5.07	4.63	4.72	4.82	5	4.58
Total weight ÷ total heating surface	82.5	75.5	63	75	56.5	70	57.5
Tractive effort × diam. drivers ÷ total H. S.	720	713	666	720	513	650	546
Vol. equivalent simple cylinders	9.9	11.5	11.5	11.4	8.93	9.4	8.93
Total H. S. ÷ vol. equivalent cylinders	294	265	312	261	405	305	387
Grate area ÷ vol. equivalent cylinders	4.3	4.3	4.62	3.8	6.33	5.9	5.62
Reference in AMERICAN ENGINEER	This issue	1905, p. 246	1905, p. 454	1906, p. 392	1905, p. 287	1906, p. 73	1904, p. 166

COMPARATIVE DIMENSIONS OF BALANCED COMPOUND LOCOMOTIVES.

fully built and applied by this company for a number of years. The general dimensions, weights and ratios are as follows:

COLE BALANCED COMPOUND PACIFIC TYPE LOCOMOTIVE.

NORTHERN PACIFIC RAILWAY.

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Passenger
Fuel	Bit. coal
Tractive effort	30,340 lbs.
Weight in working order	240,000 lbs.
Weight on drivers	157,000 lbs.
Weight of engine and tender in working order	380,500 lbs
Wheel base, driving	12 ft.
Wheel base, total	33 ft. 5 in.
Wheel base, engine and tender	62 ft. 10 in.

RATIOS.

Weight on drivers ÷ tractive effort	5.18
Total weight ÷ tractive effort	7.9
Tractive effort × diam. drivers ÷ heating surface	720
Total heating surface ÷ grate area	67
Firebox heating surface ÷ total heating surface, %	8.3
Weight on drivers ÷ total heating surface	53.8
Total weight ÷ total heating surface	82.5
Volume of equivalent simple cylinders	9.9 cu. ft.
Total heating surface ÷ volume equivalent cylinders	294
Grate area ÷ volume equivalent cylinders	4.3

CYLINDERS.

Kind	Balanced Compound
Number	4
Diameter and stroke	16½ & 27½ x 26

VALVES.

Kind	Piston
Diameter	14 in.
Greatest travel	6 in.
Outside lap	1 in.
Inside clearance	H. P., 5-16 in.; L. P., ⅜ in.
Lead in full gear	¼ in.

WHEELS.

Driving, diameter over tires	69 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	11 x 11½ in.
Driving journals, others, diameter and length	9½ x 12 in.
Engine truck wheels, diameter	33½ in.
Engine truck journals	6½ x 12 in.
Trailing truck wheels, diameter	45 in.
Trailing truck, journals	8 x 14 in.

BOILER.

Style	E. W. T.
Working pressure	220 lbs.
Outside diameter of first ring	72¼ in.
Firebox, length and width	96 x 65¼ in.
Firebox plates, thickness	⅜ in.
Firebox, water space	F4½-S -B4 in.
Tubes, number and outside diameter	306 2-in.
Tubes, length	16 ft. 9 in.
Heating surface, tubes	2,667 sq. ft.
Heating surface, firebox	241.8 sq. ft.
Heating surface, total	2,908.8 sq. ft.
Grate area	43.5 sq. ft.
Smokestack, diameter	18 in.
Smokestack, height above rail	15 ft. 5½ ins.
Center of boiler above rail	115 in.

TENDER.

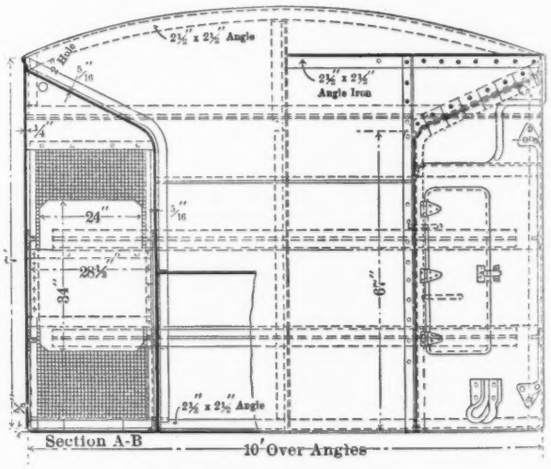
Tank	Water bottom
Frame	13-in. channels
Wheels, diameter	33½ in.
Journals, diameter and length	5½ x 10 in.
Water capacity	7,000 gals.
Coal capacity	12 tons

POOL VS. REGULAR CREW.—If you examine the reports made to the Interstate Commerce Commission by the different trunk lines showing the amount of money expended to keep each locomotive in repair for the year ending June 30, 1905, you will find two of the large trunk lines where they keep regular crews on their engines making the best showing of all railroads in the United States, and these two roads have a reputation second to none in point of good service.—*Committee Report on Pooling Engines, Traveling Engineers' Association.*

7,000 GALLON TENDER.

LOUISVILLE & NASHVILLE RAILROAD.

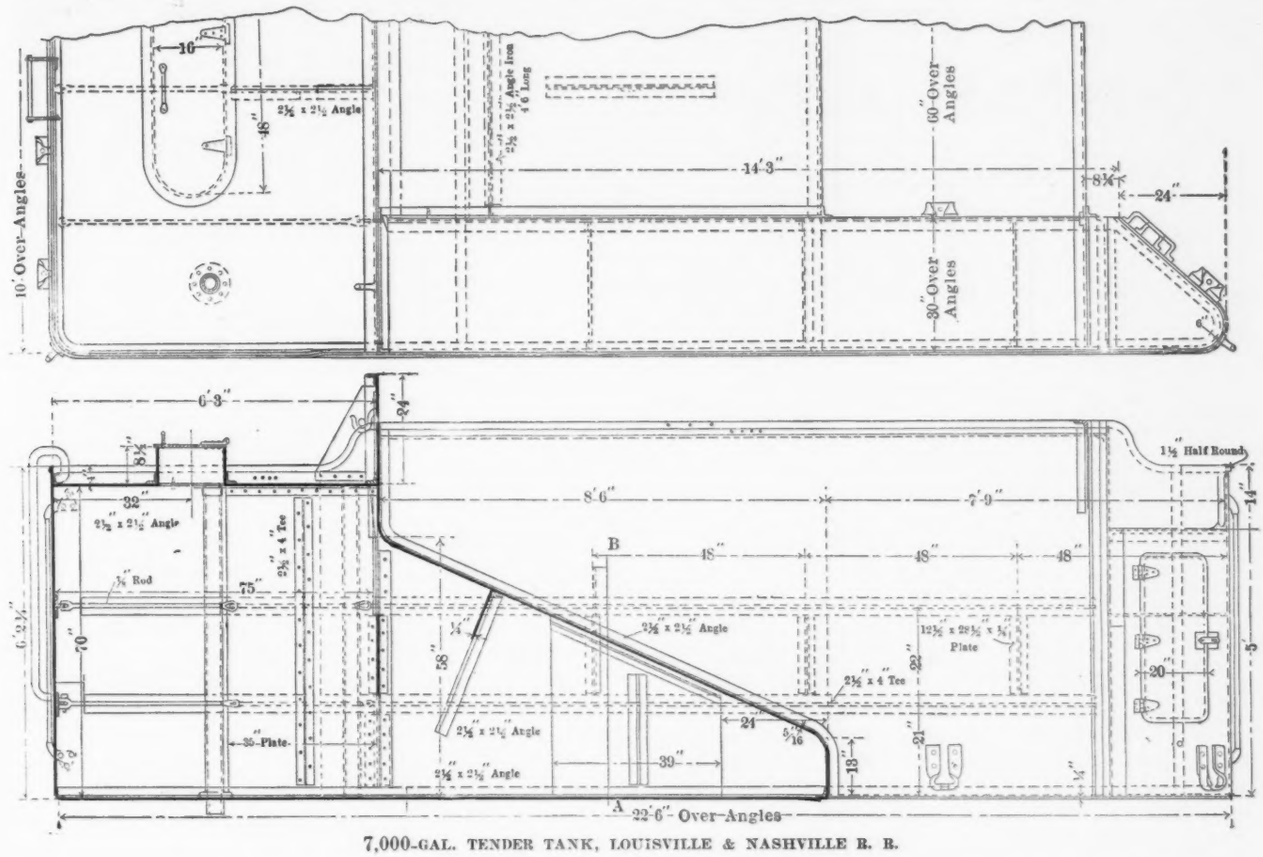
The standard 7,000-gal. tender of the Louisville & Nashville Railroad, illustrated herewith, has several interesting features of design. The sheets forming the sides of the coal space are in one piece, extending from the bottom of the tank to the top of the outside side sheets, to which they are riveted. This construction not only simplifies and reduces the cost of erection, but also reduces the amount of material required. It also presents a much neater and cleaner appearance than where the vertical part of the coal space side sheet is connected to the outside sheet by a slope sheet extending to the top of the side sheet and a horizontal sheet extending to the side sheet, both the slope and the horizontal sheets being riveted to an angle riveted to the top of the coal space side



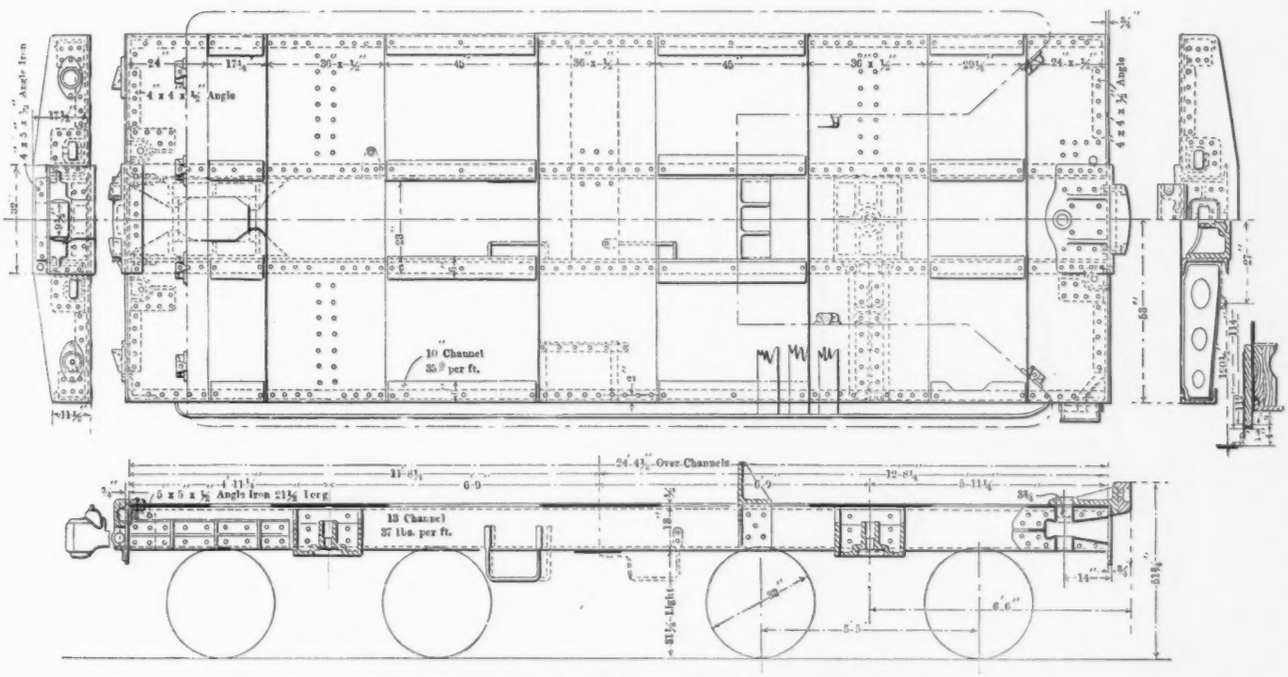
END ELEVATION OF TANK.

sheet. The vertical part of the sheet does not end where it is riveted to the slope sheet forming the bottom of the coal pit, but extends downward to the floor sheet, to which it is connected by an angle-iron, thus greatly stiffening the tank. Additional braces for the bottom of the coal space are also provided, as shown. The sides and ends of the tank are stiffened by the 2½x4-in. T's, which are riveted to them by 7-16-in. rivets, 6-in. pitch. The water in passing forward into the legs of the tank passes through the screens of 2¾x2¾-in. mesh, No. 11 B. W. G.

The center sills of the tender frame consists of 13-in. channels, 37 lbs. per foot, and the side sills are 10-in. channels, 35 lbs. per foot. The castings connecting the center sills at the bolsters are of cast steel, while those connecting the center and side sills are cast iron. Cover plates 36 ins. wide and ½ in. thick extend across the frame at the bolster, securely tying the various parts together. There is also a cover plate of this size extending across the top of the frame at the center and cover plates 24 ins. wide and ½ in. thick at each



7,000-GAL. TENDER TANK, LOUISVILLE & NASHVILLE R. R.



7,000-GAL. TENDER FRAME, LOUISVILLE & NASHVILLE R. R.

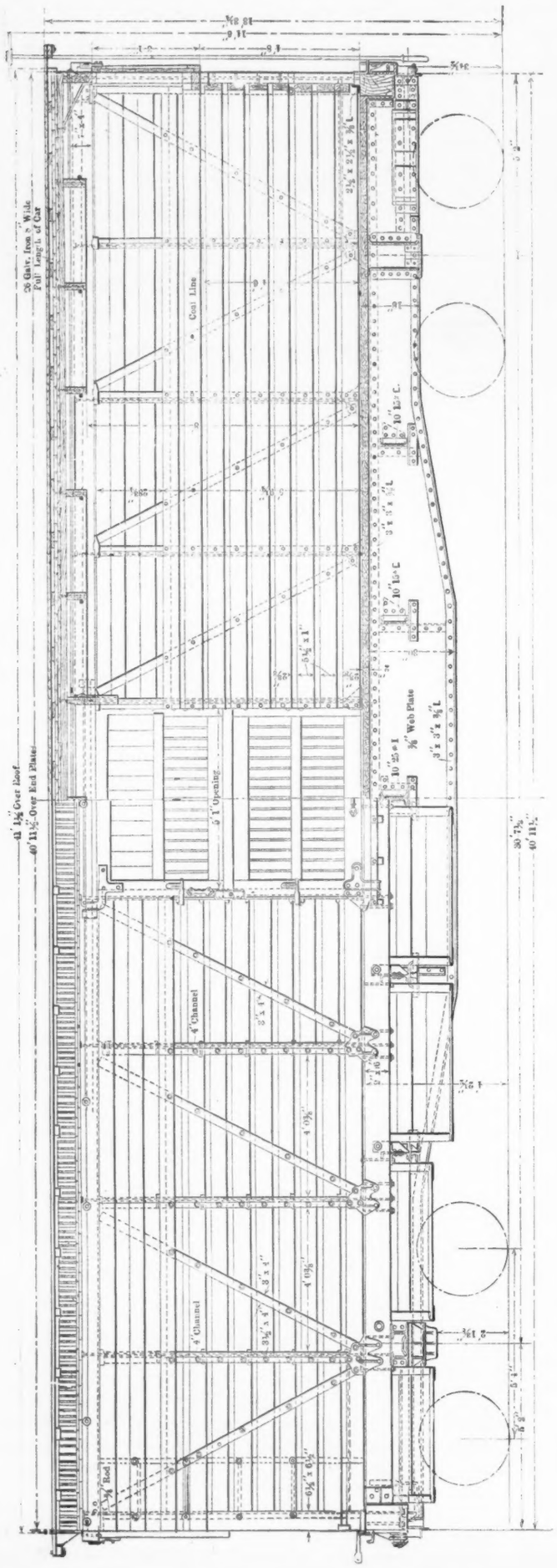
end. The end sills are ¾-in. plates connected to a ½-in. cover plate by 4 x 4 x ½-in angles, and to the center and side sills by heavy angle plates, as shown. The center sills are spaced 23 ins. apart, and the steel draft casting at the rear end is arranged to take the Session-Standard friction draft gear. We are indebted for information to Mr. T. H. Curtis, superintendent of machinery, and Mr. Walter H. Stearns, mechanical engineer.

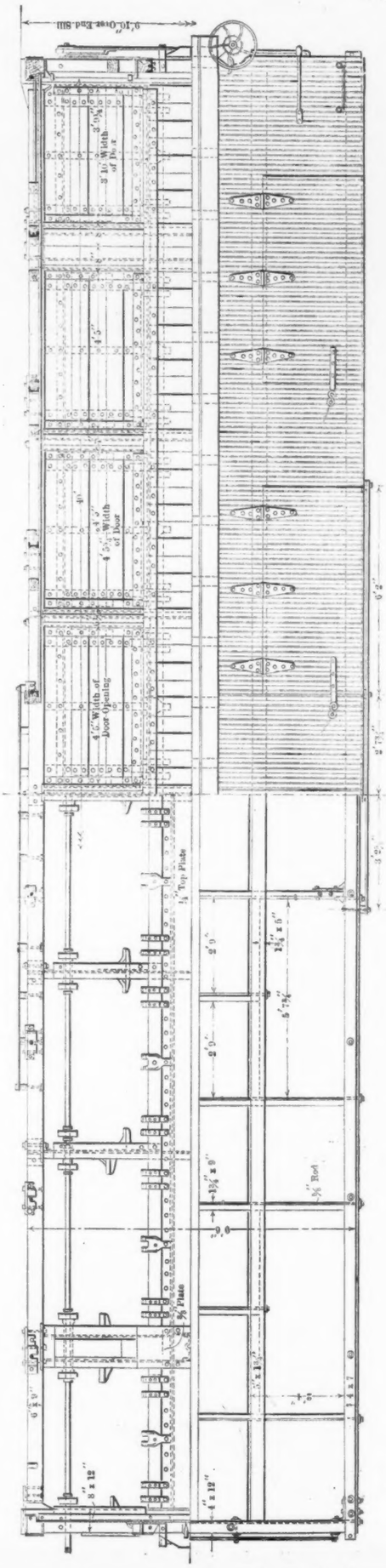
The committee makes the following conclusions, and recommends as general principles of practice that:

The circular form of an engine house is, in general, the preferable design, with possibly the following exceptions:

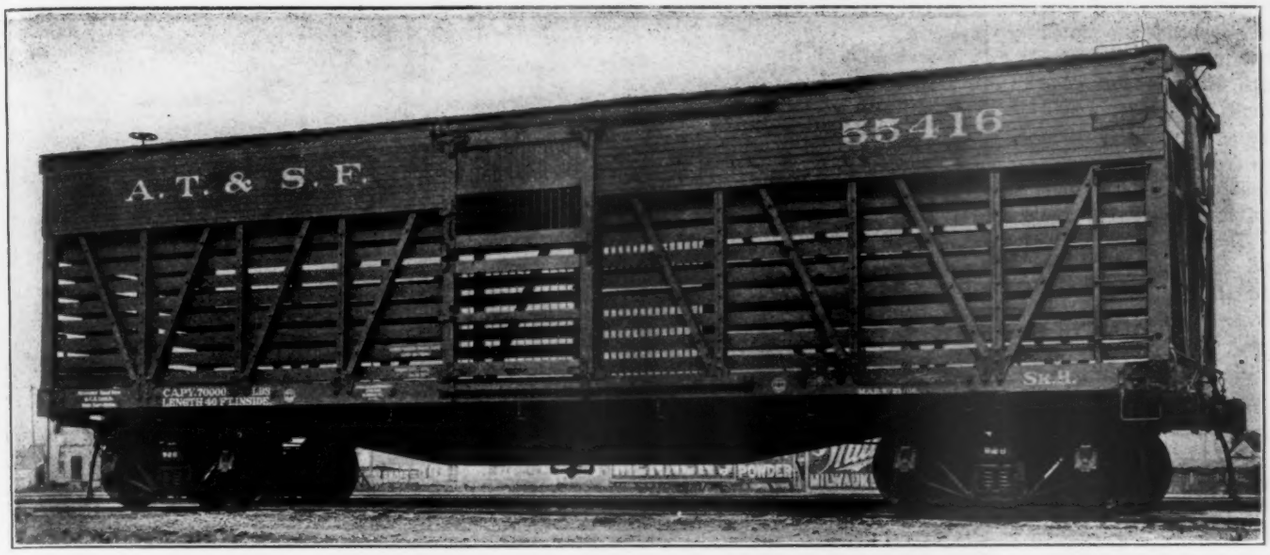
(a) At branch terminals, or similar points, where not more than three or four locomotives are housed at one time and where it is more economical to provide a "Y" track than a turntable, or where it is not necessary to turn the locomotives, a through rectangular house, with switches at one end only, may be desirable, or

(b) At shops where a transfer table is used and an engine house is to be added, and at special locations, the transfer table house may be desirable.—*American Railway Engineering and Maintenance of Way Association.*





35-TON STOCK AND COKE CAR WITH STEEL UNDERFRAME, ATCHISON, TOPEKA AND SANTA FE RY.



35-TON STOCK AND COKE CAR WITH STEEL UNDERFRAME—ATCHISON, TOPEKA & SANTA FE RAILWAY.

35-TON STEEL UNDERFRAME STOCK AND COKE CAR.

ATCHISON, TOPEKA & SANTA FE RAILWAY.

The Atchison, Topeka & Santa Fe Railway has recently had built at the Madison works of the American Car & Foundry Company a number of 40-ft., 70,000-lb. capacity combination stock and coke cars with steel underframes. They have drop bottoms on each side of the center sills for the entire length of the car, and these, in connection with eight large doors in the roof, make it possible to handle coke as well as stock. The drop doors may be locked so that it is impossible for them to be opened accidentally. One of the cars filled to the roof with coke can be unloaded in about 15 minutes, this including the time for closing the doors and placing the car in service condition, but it is expected that this time will be considerably shortened when those who operate the doors become more familiar with them. The cars have doors just above the floor at the ends so that, in addition to handling stock, coke, coal, ties and lumber, they may readily be loaded with rail, pipe or other long material.

They weigh about 43,000 lbs. each and have the following general dimensions:

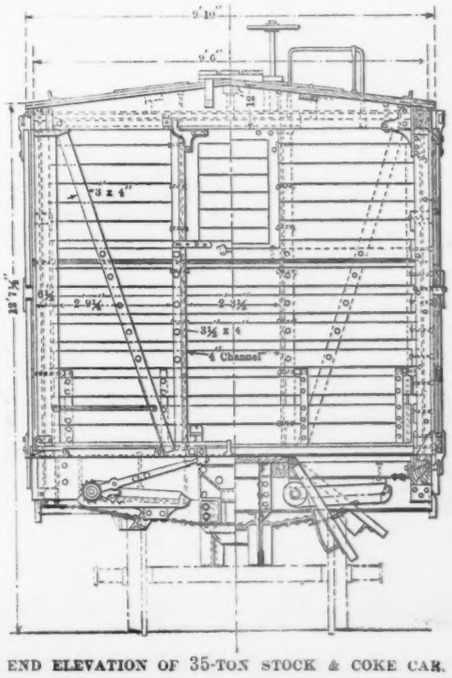
Length over end sills	40 ft 11½ ins.
Length inside	40 ft.
Width over side sills	9 ft. 6 ins.
Width at eaves	9 ft. 10 ins.
Width inside	8 ft. 8 ins.
Height inside, clear space	7 ft. 9 ins.
Height top of rail to top of running board	13 ft. 3¼ ins.
Height top of rail to top of eaves	12 ft. 7½ ins.
Wheel base of car	35 ft. 11½ ins.
Wheel base of truck	5 ft. 4 ins.
Distance between centers of trucks	30 ft. 7½ ins.

The center sills are continuous for the entire length of the car and consist of ⅝-in. plates with 3 x 3 x ⅝ in. angles riveted at the top, on the outside, and two 3 x 3 x ⅜ in. angles riveted at the lower edge, as shown on the drawing. These sills are reinforced by a ¼-in. cover plate and are 30 ins. deep for about 9 ft. at the center of the car, tapering to 18 ins. at the bolster. The side sills are of 6 x 9-in. long leaf yellow pine and are secured to the end sills by malleable iron pockets. At the center of the car is a 10-in. 25-lb. I beam, forming a crosstie and passing through the center sills, to which it is fastened by means of angle plates. The ends are cut to receive the side sills, to which they are attached by angle plates, which form a bearing for the sills. There are four other crossties, consisting of 10-in. channels, which are secured to the center and side sills in like manner.

The body bolsters are built up of pressed steel diaphragms, those between the center sills being of ⅝-in. steel and those between the center and side sills of 5/16-in. steel. They are reinforced at both the top and bottom by ⅜-in. plates 14 ins. wide. The slots in which the door operating shaft works are reinforced by ⅜ x 2-in. plates, and there is a 3/16-in. pressed steel filler between the diaphragms.

The end sills are of 8 x 12-in. white oak, secured to the center and side sills, as shown. Miner tandem rigging is used. The floor supports, 5 x 4 ins., are bolted to the crossties, bolsters and sills. The flooring is 2 ins. thick, and is protected around the door openings by steel plates. A modified form of the Caswell drop-door mechanism is used. Ratchet levers at each end of the car operate 2-in. shafts. Pinions on these shafts engage with racks and, as the shafts are revolved, they move inward or outward, thus opening or closing the doors, as the case may be. The shafts are fitted with roller bearings, which come in contact with the door, as shown on the drawing.

The side posts are 3½ x 4-in. and the corner posts 6½ x 6½-in. The side and end posts are plated on one side with 4-in. channels, secured to them by ½-in. bolts. The ends of the posts are fitted to malleable iron shoes and caps. The side door openings are 5 ft. 1 in. x 7 ft. 9 ins.; the end door openings are 2 ft. 3½ ins. x 2 ft. 10 ins. There are eight roof doors, each having an opening 2 ft. 4 ins. x 5 ft. 7¾ ins. The roof

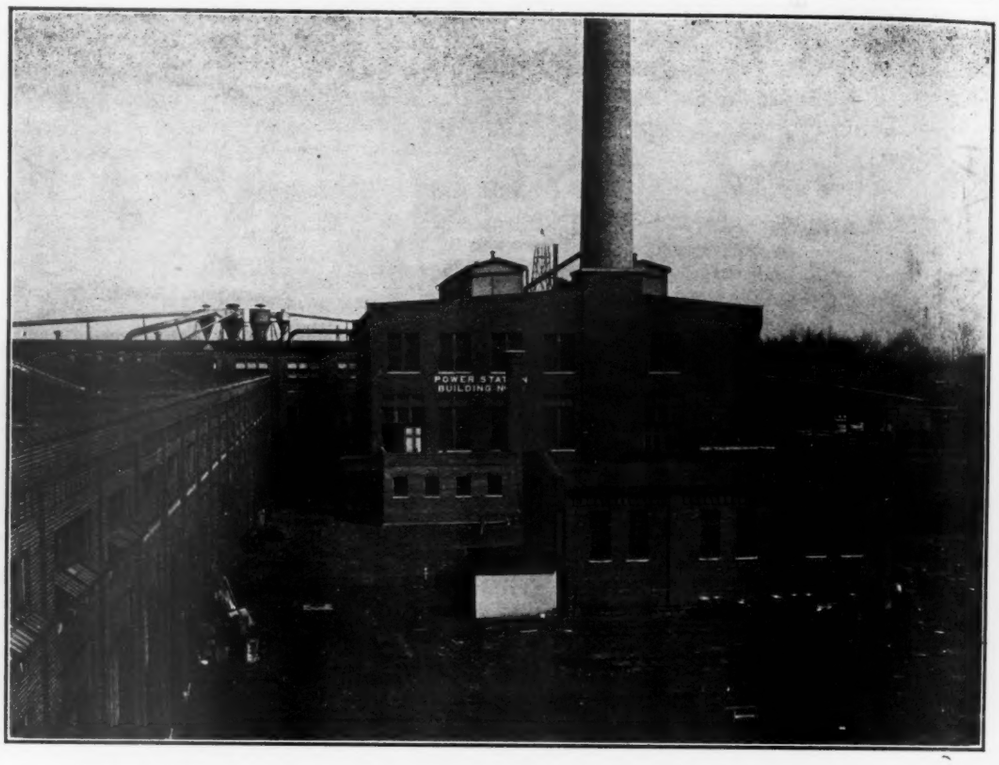


END ELEVATION OF 35-TON STOCK & COKE CAR.

door openings are plated with iron and provided with water grooves. The trucks are the standard Santa Fe type for 35-ton freight cars. We are indebted for drawings and information to Mr. A. Lovell, superintendent of motive power, and Mr. E. Posson, engineer of car construction.

WALSCHAERT VALVE GEAR.—Engine failures due to the breaking of valve motion connections during twelve months' service have been very slight. With fifteen engines equipped with the Walschaert valve gear we have had only three failures that were chargeable to valve motion failing, while with engines equipped with the Stephenson link motion we have had at least three times as many failures due to the link motion getting out of order.—*O. H. Rehmeyer, before the Traveling Engineers' Association*

TECHNICAL INSTRUCTION FOR RAILWAY EMPLOYEES.—Mr. J. F. Dunn, superintendent of motive power of the Southern Pacific Lines East of Sparks, has arranged with the University of Nevada at Sparks to establish classes for apprentices to be held every Monday and Tuesday mornings from 7 to 9 o'clock, and also for mechanics, car men, etc., to be held every Monday and Tuesday evenings from 7 to 9 o'clock. The classes will receive instruction in arithmetic, elementary mechanics, mechanical drawing, link motion and valve gears.



POWER HOUSE WITH PAINT STORE HOUSE IN FOREGROUND,—COACH SHOP AT THE LEFT.

SOUTH LOUISVILLE SHOPS.

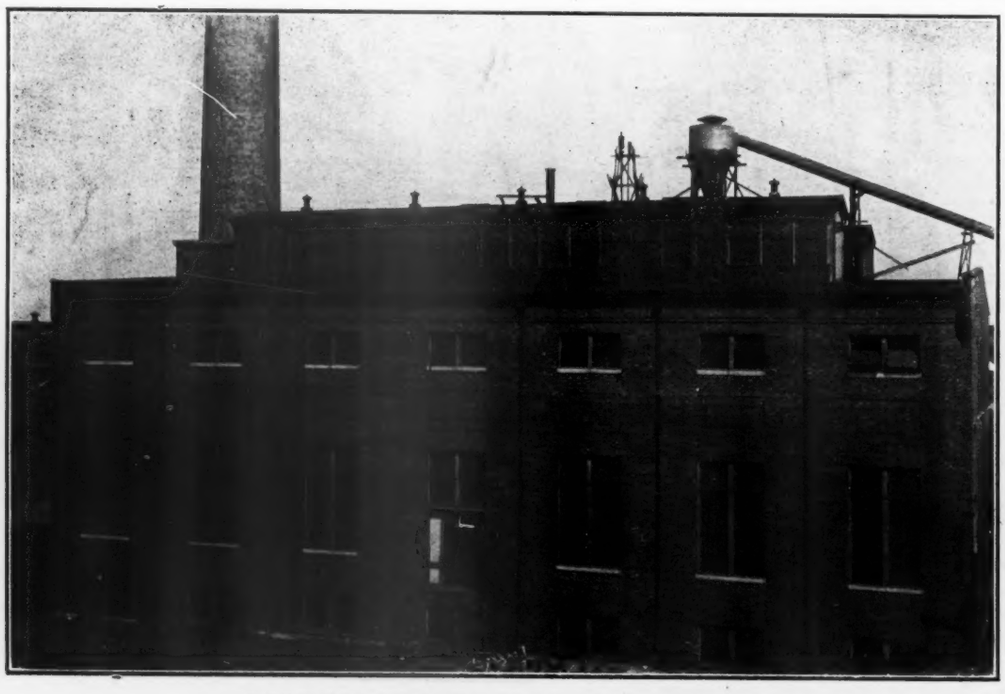
LOUISVILLE & NASHVILLE RAILROAD.

III.

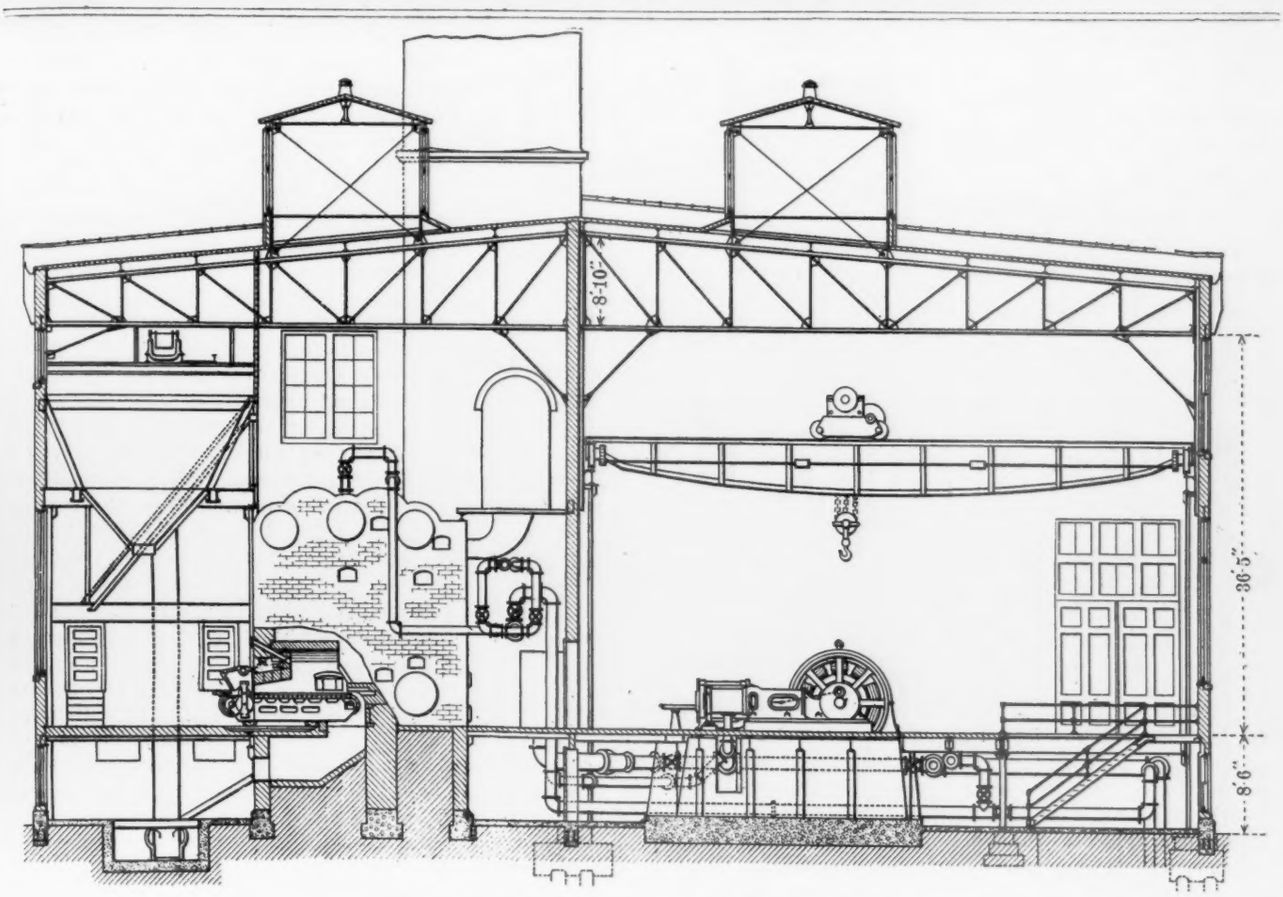
POWER HOUSE.

The power house, while it is apparently located a considerable distance south of the center of gravity of the power distribution, is not as far from it as would appear, since the amount of power required to operate the machines and the shaving exhaust system in the planing mill is quite large compared to that used in any of the other shops, not excepting the locomotive shop. Condensors were not installed, as practically all of the exhaust steam is used by the heating system and in the dry kiln. The piping is very carefully arranged to take care of any emergency and prevent a shutdown in case of accident.

Building.—The power house is a steel frame brick building, 110 ft. by 141 ft. 4 ins., divided by a 13-in. brick wall into a boiler room 48 ft. 8 ins. by 139 ft. 2 ins. and an engine room 58 ft. 1 in. by 139 ft. 2 ins. Over each room is a monitor 7 ft. 10 ins. high and about 15 ft. wide, extending almost



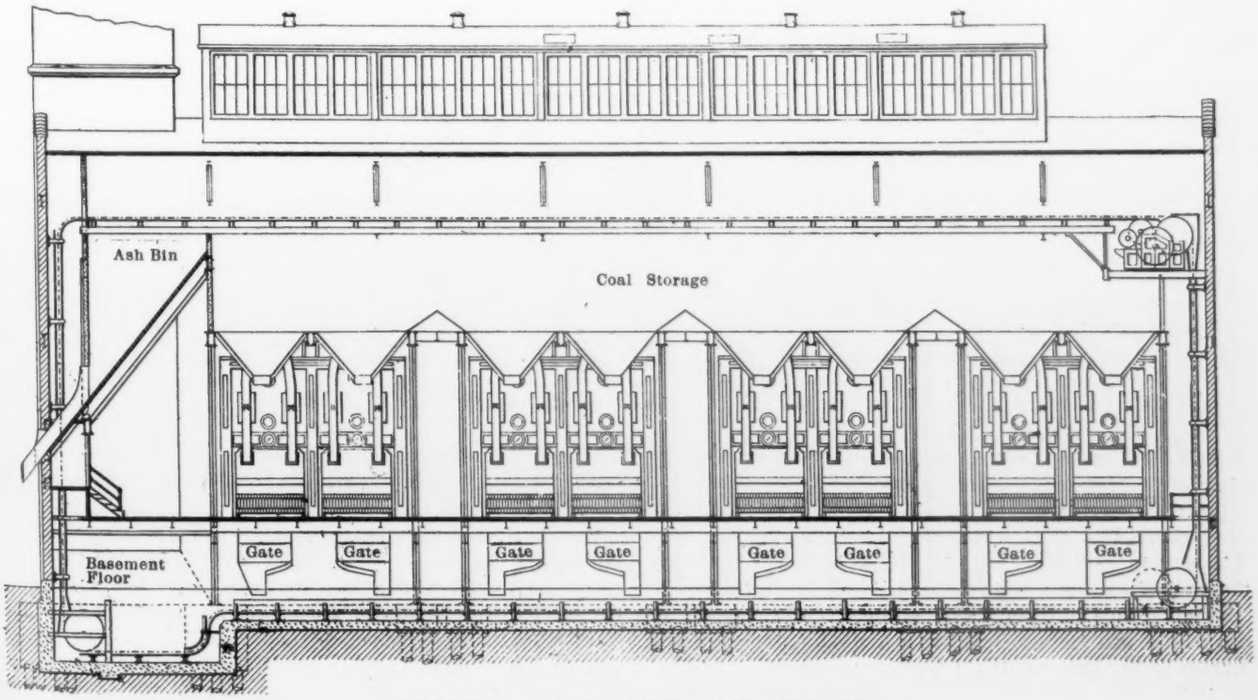
POWER HOUSE—VIEW FROM TOP OF LUMBER SHED.



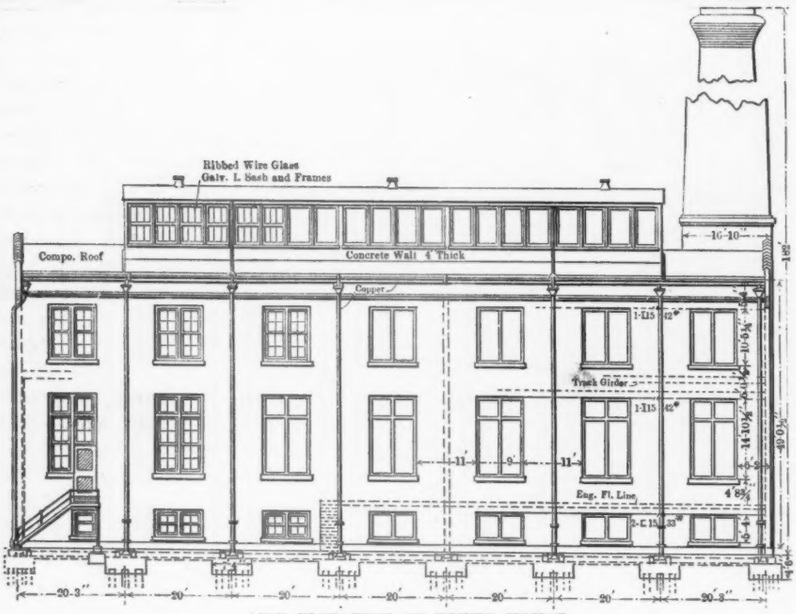
CROSS-SECTION THROUGH ENGINE AND BOILER ROOM.

the entire length of the building. The engine room floor is 8 ft. 10½ ins. above grade and the height from the floor to the underside of the roof trusses is 36 ft. 5 ins. The engine room is equipped with a 5-ton traveling crane (56-ft. span), operated by hand, the runways of which are supported by columns independent of those of the building. The roof purlins consist of 10-in 25-lb. I beams, the wall and ridge purlins of 10-in. 15-lb. channels and the rafters of 2¼ by 2¼ 4.9-lb. T's. A composition roofing is used.

The floor is of concrete, supported by 15-in. I beams, which are in turn supported by cast-iron columns and, wherever possible, by the machinery foundations. The floor of the basement is slightly above grade and consists of concrete laid on a bed of cinders. The basement is lighted by a number of small windows. The window sills are of concrete, and all wood in connection with the windows and doors is covered with galvanized iron, thus making it fireproof. The wainscoting of the engine room is 9 ft. high and of brown pressed



LONGITUDINAL SECTION THROUGH THE BOILER ROOM.



SIDE ELEVATION OF POWER HOUSE.

brick laid in black mortar, except the first four courses just above the floor and two at the top, which are of black brick. The remaining part of the wall is of yellow pressed brick. The coal storage bins and the conveying machinery are supported by a special steel construction.

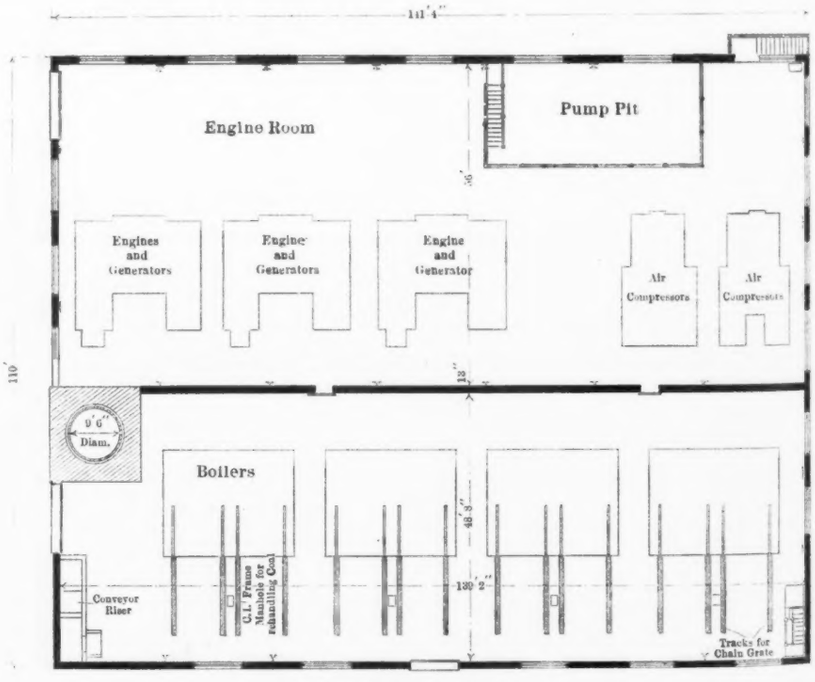
Boilers and Stokers.—There are eight Sterling stokers, each of 305 h.p.; six are equipped with Green chain grate stokers, and two of these, as well as the remaining two of the eight, are arranged for burning the sawdust and shavings from the planing mill, the shavings being fed directly upon the grate through a pair of 6x12-in. spouts, which enter the furnace just above the rear of the igniting arch. The shavings are forced from the galvanized iron storage pockets on the roof of the planing mill by means of a blower system. Power for operating the stokers is furnished by a 6-h.p. Kriebel oscillating engine. Each stoker has an active grate area of 67.5 sq. ft., and is designed to burn bituminous slack. The ashes are raked from the pits into chutes, which deposit them in the conveyor. The concrete slab which partially covers over the top of the ash pit catches the unconsumed coal which drops through the grates, and is also used in connection with a brick damper to shut off the cold air at the back of the grate.

Just outside of the boiler room door at the south side of the building is an elevator, as shown on one of the photographs, by which wood from ends of timber from the planing mill, or other material, may be raised from the ground level to the level of the boiler room floor. It is operated by hydraulic power.

Chimney.—The chimney is 182 ft. high, with a flue 9 ft. 6 ins. in diameter. For a height of 60 ft. the wall is 40 ins. thick, and the cross-section of the chimney is square; above this the cross-section becomes circular. The wall is built in sections 16 ft. 5 ins. in length. The thickness of the wall of each succeeding section is made smaller, until for the top section it is only 8⅝ ins. thick. The chimney is topped with a cast iron cap. It has a fire brick lining carried on bracket projections, making it possible to renew any section of the lining without disturbing the rest, and allowing for expansion in the various parts. It was built by the Alphons-Custodis Chimney Company of New York, of perforated radial bricks, made from a specially selected clay, burned in a high temperature, to render them dense and impervious to moisture. Opposite the opening for the flue is a balance opening of the same shape and size in order that the settlement on the two sides will be equal, and therefore prevent cracking or canting over of the chimney. The balance opening is closed on the outside by a dummy wall.

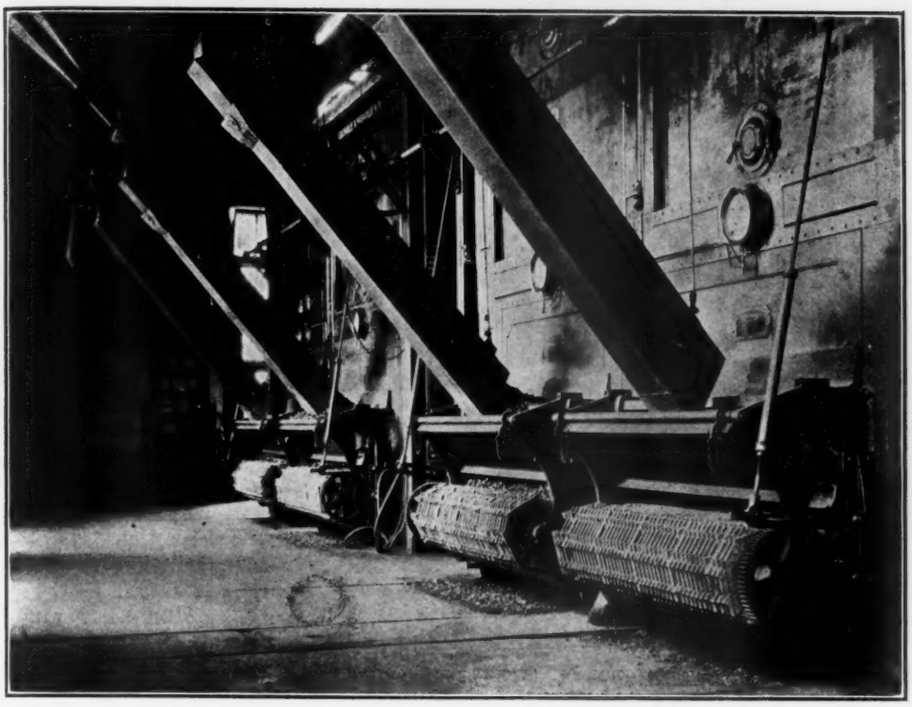
Coal and Ash Conveyor.—The coal is fed to the stokers from overhead storage pockets of steel and concrete construction, which have a capacity of 1,000 tons, or sufficient to operate the plant for at least three weeks. The coal is delivered to the power house over the track extending along the western side of the building. It is shoveled from the cars into curved chutes, which conduct it to a crusher and feeding device, after which it passes into the conveyor. The coal crusher is operated by a 20-h.p. General Electric motor. The conveyor is of the Peck overlapping pivoted pocket type, was installed by the Link Belt Machinery Company of Chicago, and travels at the rate of 40 ft. per minute, delivering 40 tons of coal per hour. The ashes are conveyed to an overhead ash bin, which, when filled, may be loaded by gravity directly into gondola or hopper cars placed on the track alongside of the building.

Boiler Feed Water.—In one corner of the boiler room is a receiver tank for returns from the steam piping and warm water from every source. Just outside of the boiler house is located a hot well, which takes the discharge of the cooling water from the air compressors. A Reilly pump is used to



PLAN OF POWER HOUSE.

supply the receiving tank with water from this hot well to make good leakage or waste from the system. Water flows from the receiver tank into a Cochrane feed water heater by gravity, and is drawn from this by two Laidlaw-Dunn-Gordon boiler feed pumps, 16 and 8x10 ins. of the duplex, outside packed, plunger pattern. Between the feed pump section and the feed water heater is placed a reservoir tank in order to furnish a supply on which the boiler feed pumps



BOILER ROOM SHOWING ARRANGEMENT OF STOKERS.

may draw in case of an emergency. The feed water heater is of 2,000-h.p. capacity, and while it is large enough for ordinary conditions it is sometimes emptied under extraordinary demands, and it is for this reason that the reservoir is placed between the heater and the pump. The reservoir tank is 4 ft. in diameter and 10 ft. high. To regulate the action of the feed water pumps and insure the maintaining of the water line in the boilers at a constant level two Vigilant feed water regulators, manufactured by the Chaplin-Fulton Manufacturing Company of Pittsburgh, have been installed.

Piping.—The piping for the engines and compressors passes directly through the floor into the basement, and the engine room with no overhead piping thus presents a rather unique appearance. At the rear of the boilers is the main steam header (12 ins.), divided into two sections. Each main header is connected in parallel with a 6-in. auxiliary line, and the two main headers are also connected by a 6-in. line, while the two inner batteries of boilers are connected by an 8-in. line. The use of the large and small parallel mains takes care of the expansion strains, and allows the use of smaller pipe than would otherwise be necessary. This system of piping will take care of almost any emergency, and it also keeps all of the piping warm and avoids the necessity of having to cut cold headers into the system and the consequent trouble due to condensation in the pipes. A 10-in. steam main furnishes live steam for the shops. There are no slip joints in any line of piping.

Engines and Generators.—There are three Buckeye cross compound 18¾ and 32½x12-in. engines, each direct connected to a Bullock type I 350-k.w. generator, furnishing 1,400 amperes at from 240 to 250 volts. An interesting feature in connection with the generators is the brush oscillating device. The brushes are carried on the usual ring rigging placed in bearing wheels, which are revolved slowly, and are forced along their axes until they have moved about ½ in., when they are released and returned to their former place by a spring. By continually repeating this process the brushes are prevented from wearing grooves in the commutator.

Air Compressors.—Two Ingersoll-Sergeant air compressors of the two-stage type, and having cylinders 18 and 24x21 ins., are provided. They each have a capacity of 1,400 cu. ft. of free air per minute. Air is supplied to the shops at 100 lbs. pressure, and no reservoir or receivers are used for the compressed air, as the volume of the 10-in. pipe (1,000 ft. long) conveying the air to the different shops is sufficient to steady all pulsations and provide what storage space is needed.

Pumps.—The service, fire and high-pressure pumps are located in the basement, but the engine room floor is cut away above them, as shown on one of the illustrations.

A Laidlaw-Dunn-Gordon pump, with 12 and 18½x18-in. steam cylinders and 12-in. water cylinders, is used as a service pump for supplying water for the entire plant. It is of the duplex compound type, with steam cylinders in tandem, and controlled by a Fisher governor.

BASEMENT OF BOILER ROOM SHOWING COAL AND ASH CONVEYER.

ENGINES AND GENERATORS.

The fire pump is of the Laidlaw-Dunn-Gordon make of the simple duplex type, and has 18 and 10x12-in. cylinders, with a capacity for half a million gallons per hour. The exhaust of this pump is open to the atmosphere.

A Snow pump for furnishing pressure for the hydraulic riveters has 20 and 4x12-in. cylinders, and furnishes 1,500 lbs. pressure. The accumulator is in the boiler shop.

There are also two Marsh vacuum pumps for pumping the water from the return mains of the heating system.

Switchboard.—The switchboard was built by the Western Electric Company to plans prepared by Mr. Ward Barnum, electrical engineer of the railroad. It consists of nine panels of red Tennessee marble, each 30 ins. wide, except the bus bar tie panel, which is 36 ins. wide. The three generator panels are at the left, each having at the top a double pole circuit breaker, below which is a 2,500-amp. ammeter, a rheostat handle and a double throw switch. At the left of the switchboard are two swinging voltmeters for use in throwing in a generator. To the right of the generator panels are two instruments panels; the first has two totalizing ammeters, one for light and the other for power, voltmeter switches for connecting the two swinging-arm voltmeters, and, at the bottom, tie switches for throwing the lights either on high or low bus bars, as may be desired. The second instrument panel has two recording voltmeters, a 4,000-ampere integrating watt-meter for power circuits and a 2,000-ampere instrument for the lighting circuits. The ground detecting devices are placed upon this totalizing panel. These consist of an instrument switch, one for each bus, arranged so that readings across the bus bars and from either bus to ground are made on the station voltmeter mounted at the end of the switchboard. On the right hand end of the board are four feeder panels, each of which contains a 2,000-ampere ammeter for power, a 600-ampere ammeter for lights and the circuit breakers, which act also as switches for power and light feeders.

IMPROVEMENTS TO THE SUEZ CANAL now under way include an increase of depth throughout to 31 ft. and the bottom width to 128 ft., which will permit an increase of speed of vessels passing through it from six to nine miles per hour. This will enable ships to make the passage through the canal in 12 hours, about 6 hours less than at present.—*The Engineering Record.*

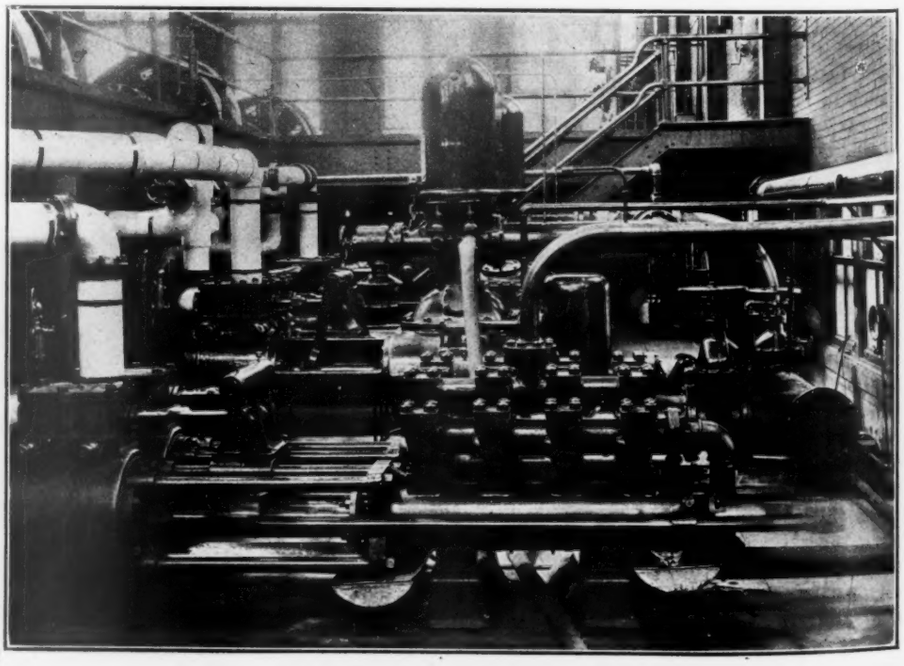
CAR FERRIES.—There are now thirty-five companies operating car ferries in North America, and they cover 1,360 miles of territory. Nine years ago there were only 197 vessels in service, with an aggregate capacity of 2,069 cars; now there are 562 boats, with a capacity of 5,615 cars. The average number of cars carried daily by all lines is about 11,500.

CHECKING INTAKE AND OUTPUT OF MATERIAL DELIVERED TO SHOPS.*

BY J. H. CALLAGHAN.

The Angus shops of the Canadian Pacific Railway, located at Montreal, are the largest group of railway shops on the continent, covering as they do an area of 250 acres, with 17 acres under roof, and consisting of the following shops: Locomotive erecting and machine shop, gray iron foundry, wheel

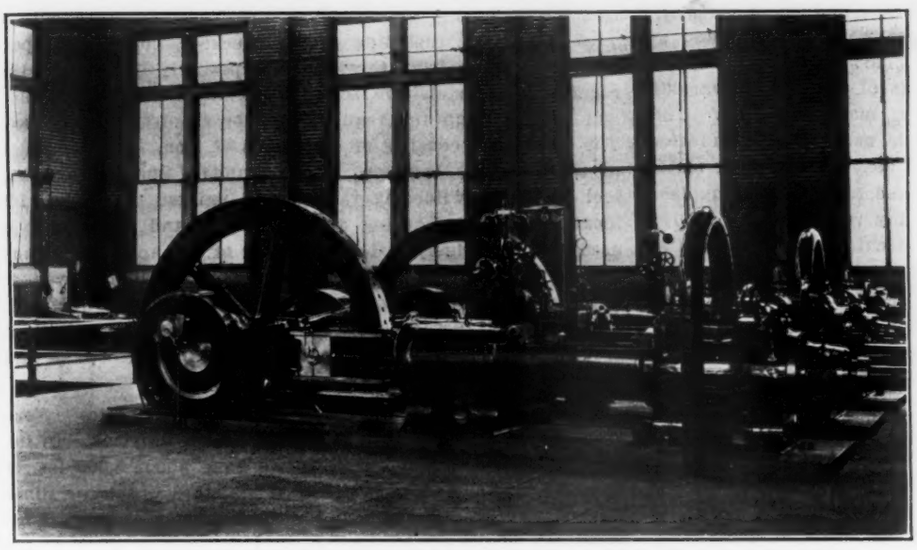
*Abstract of a paper presented at the recent convention of the Railway Storekeepers' Association. The part referring to the wheel foundry, the frog and switch shop, paint and lumber, has been omitted. The Angus shops were described in the AMERICAN ENGINEER AND RAILROAD JOURNAL as follows: General arrangement, December, 1904, page 451; buildings, January, 1905, page 1; and Feburary, 1905, page 37; power plant, March, 1905, page 75; truck shop, car machine shop, freight car erecting shop planing mill and passenger car shops, April, 1905, page 114; locomotive shop, May, 1905, page 161, and June, 1905, page 219; foundries, September, 1905, page 326; blacksmith shop, October, 1905, page 363.



HIGH PRESSURE, SERVICE AND FIRE PUMPS.

foundry, frog and switch shop, blacksmith shop, car machine shop, car truck shop, freight car erecting shop, planing mill, cabinet shop, upholstering shop, passenger car erecting and paint shop, passenger car repair shop. In order to allow of my giving an accurate idea of the system of shop requisitions and store orders in use, covering the intake and output of material supplied to and delivered from the various shops, I will treat each unit separately.

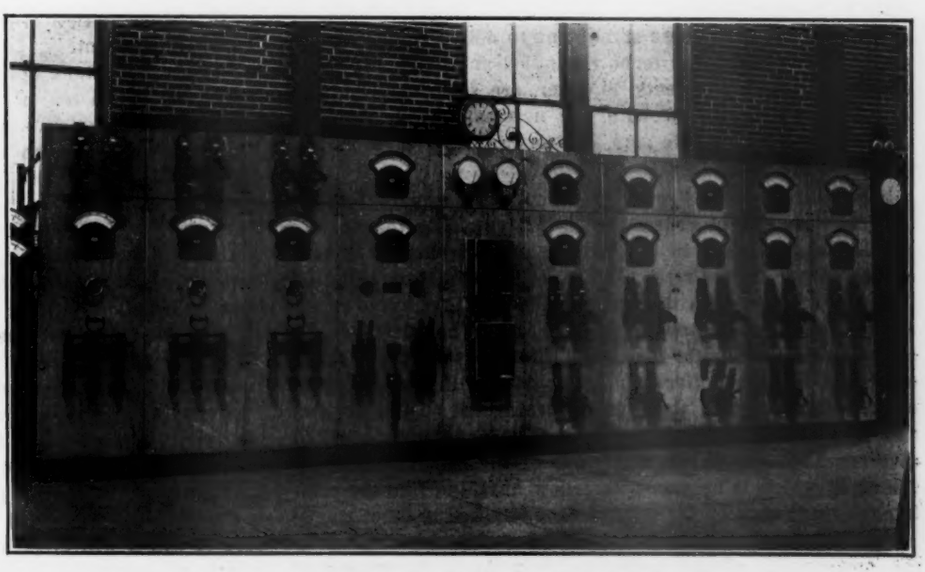
Locomotice Erecting and Machine Shop.—In this shop new locomotives are built, engines are repaired and locomotive parts, coach trimmings, water tank parts, roundhouse drop jacks, etc., are manufactured and delivered to the stores department for shipment to the various points on the entire



GENERAL VIEW OF AIR COMPRESSORS.

system. To meet the ever-increasing demands for material to keep this shop moving I have no less than four petty stores in and about it, namely, petty general store, located in center of building; petty paint store, located near tender and cab section in shop; also stock of steel plates, angles, tees, tires, bolsters, wheels, etc., located outside west end of shop contiguous to boiler shop section and stock of boiler tubes, dry pipes, superheating pipes, etc., located outside of building, but immediately adjacent to tube furnaces and steam fitters' section. All of these stores are under charge of storemen, and the business transacted in connection with them is carried on in precisely the same manner as if the deliveries to the shop were made from the general store building. Stock books are carried in each of them, together with day books, into which a correct record of all receipts and disbursements are posted, which at the end of each month are summarized and posted into stock book before the same is turned into the general store to allow of correct compiling of the regular monthly requisitions on the general purchasing agent. The forms of shop requisitions known and variously described as shop requisition form M and shin plaster are in general use throughout the plant, so also is the form covering goods drawn for manufactured material. This form is made out and signed by the several foremen who are authorized to issue them and are given to the storemen, who supply the material. These forms are then priced and classification item and class number added to them, after which record is taken of them, and at the close of the day's business they are turned into the general store, to be included with the various other lots received from all other petty stores on the plant, and sent into the office the following morning, together with the forms covering disbursements from the general store to be posted or, rather, charged to the various accounts for which the material was required. These forms are made in duplicate, the foreman issuing them retains the duplicate, while the original is delivered to the storeman. Eventually, however, both original and duplicate find their way to the office and are there compared, one being a check against the other, so that you not only have the store form, covering the material issued, but the mechanical department's acknowledgment of its receipt. In this shop we have a group of three general disbursing accounts, namely, "repairs," which, of course, gives reference to engine numbers, steam shovels, rotary plows, etc.; "new rolling stock," which gives the equipment order numbers, and "manufactured material," covering the numerous store orders placed on the shop. Under these headings the intake of material and the output of work is checked up, posted, and cost arrived at. This is the system in general use and is a clear and simple method, and, if properly conducted by all interested, offers a very accurate solution of the cost problem. While I say this is the system in general use, there are exceptions brought about by the impracticability of applying it in conducting the department's business in connection with some of the shops, and it is for this reason I wish to treat each of the shops where such differences occur and which go to make up the whole, separately.

Foundries.—From our two foundries, grey iron and wheel, we turn out the majority of grey iron castings for the entire system and the total wheel supply for the road. Similar general accounts, namely, repairs and equipment, are handled here on the same lines as in the other shops, with the exception that all requisitions covering such accounts are merged into store orders and placed o nthe foundry by storeman in charge. To make this condition plain I will endeavor to give you an



MAIN SWITCH BOARD IN ENGINE ROOM.

outline covering the conditions under which our foundries are conducted. First of all, we aim at treating them on the lines we would an outside concern, so that we may exact from them the same (though we figure on better) service we would from outside foundries. They are operated by the car department, and the master car builder is directly responsible for their operation and output. At the same time the total intake of raw material and the output of finished castings are the property of the general storekeeper, hence the importance of checking and weighing the intake and output by store department employes. To take care of this work there are two foundry checkers and one foundry clerk, whose offices are located in the scale room, through which all material must pass on its way to the cupolas, so that nothing goes into the cupolas without first crossing the scales and being correctly weighed by my foundry clerk. These weights are posted in a book kept for the purpose and are final; no forms are given covering this material, which consists of pig iron of various brands, broken wheels, scrap, coke, manganese, etc. The same is true of the various materials used in the foundries proper, such as sands, facings, flour, etc.; in short, all material required for the operation of these foundries is supplied without the usual shop form M already referred to as applying in the locomotive, erecting and machine shop, so that the total cost covering intake of these foundries is made up from foundry clerk's scale and material issued records.

The output, allowing for shrinkages, is always a check on the intake, but, so that a correct record is arrived at, all castings made in the grey iron foundry when cleaned and ready for delivery are checked as to pattern numbers and weighed, and as each load is checked out O. K. on the scale the tally incorporating the various items making up the load is signed by my foundry checker (who retains a copy), and is handed back to the foundry foreman's representative as his authority for delivery. The loads referred to are loads of about two tons; they are usually made up so as to allow their being delivered direct to the various shops for which they were ordered without rehandling after crossing the scales. By this I mean castings for the coach shop would not be included with load for locomotive, freight car or switch shop, and in this way the foreman of the shop receiving the load accepts the check as to contents made by the foundry foreman, and my foundry checker, and delivers to the latter the shop forms M covering the load, which forms show in detail the various accounts to which the different patterns are to be charged. The shop foreman arrives at this information from the tally slip already referred to, which shows the requisition number covering the casting or castings made, taken from my order placed on the foundry. This apparently complex or detailed method of handling the grey iron foundry output is made necessary from the fact that we use this foundry as a petty store in making deliveries to the different shops, it being inadvisable from a business standpoint to deliver the total output to the general store to be rehandled and delivered to the shops. The line shipments, however, are sent from the general stores accompanied with the necessary shipping slips, and are here loaded into cars and forwarded to their several destinations.

Blacksmith Shop.—From this shop the forgings for our total new equipment orders are turned out; also the bulk of car forgings required in the keeping up of repairs of freight and passenger rolling stock. We have here bulldozers and oil furnaces, together with the various other machinery and equipment, to allow of our turning out the iron work for 600 standard box cars per month, together with new coaches and sleepers, while the locomotive side is provided with the necessary equipment to allow of the prompt turning out of new engines and locomotive repairs. These few facts are simply cited to give some idea as to the magnitude of the task attaching to the effort which is necessary to follow anything like the total intake of this shop on the regular lines followed in other shops.

You will note from the location of material about this shop the opportunity offered to get at it without the necessary requisition form. There are not only doors every few yards, but windows, and contract men are not particular as to how they get material to work with; it is simply a matter of "get it" with them; never mind the red tape. Now if we were only building cars from the output of this shop the intake question would be of little concern, but as we are repairing and manufacturing for the line it becomes absolutely essential to have accuracy not only in connection with the intake of this most perplexing problem, but absolute correctness in checking the output. So far as pertains to deliveries from our regular iron rack or house no difficulty is encountered, as the business here is handled in exactly the same manner as if issues were made from the general store.

There is in this building an office with phone communication with all petty stores, offices and shops, together with a good store staff, including proper checkers and stock-keeper. All issues made from this rack are properly covered by the regular shop requisition form M, which is priced, classified and sent through the regular channel as already described. The stock here consists of all brands of iron, from the finest to the ordinary common, all in standard market lengths; tool steel in bewildering varieties all painted or marked for identification, also spring steel, gas pipe and chain, and is used almost exclusively for the filling of line requisitions and repairs in the various shops. The iron house, however, is but a very small part of the iron problem at our works, so much so that further remarks by me in connection with it are unnecessary; it is thoroughly organized and can take care of itself.

Now to get at the greater field of iron deliveries: Your attention is called to the general lay-out of the stock. In the average standard 30-ton box car we have about 5,200 lbs. of wrought iron or mild steel, in a standard coach or diner about 23,000 lbs. We have orders on the shops at present for thousands of the former and something like a hundred of the latter. This will give you a fair idea of the amount of stock we must carry for these purposes. In ordering iron for new rolling stock we make it a practice of ordering iron cut to length for various purposes required; that is, in ordering arch bar iron instead of calling for standard bars we get pieces. The same applies to all other forgings to allow of the various sizes and kinds of iron being piled together, always keeping in mind the necessity of locating these piles convenient to the various machines through which they must pass; that is, truss rods near the upsetting and screwing machines, carry irons near the bulldozers, and so on. You will at once recognize the difficulties one must expect to meet in endeavoring to check in the requirements of this shop.

The argument has been advanced that every pound of iron entering a smith shop should be weighed in, and the finished product as it goes out should undergo the same ordeal; this so that some statistical fiend might arrive at the actual waste in scalings, turnings, borings, etc. This proposition sounds all right, and might work very nicely at a small shop, where they use about a ton or two of iron a day, but in a plant like ours its introduction would be practically disastrous. Take, for instance, bulldozers with dies all placed waiting for raw stuff to be weighed out piecemeal to them; think of the furnaces in connection with them getting away with fuel oil to the tune of 2,000 to 3,000 gals. per day, the piecework men with their hands tied, and you have some idea of what this method would mean. And then the output: Our company wants all the cars it can get into service, and as quickly as it can get them, to cope with the ever-increasing business which the unprecedented prosperity of the country has made necessary. At our present rate of building we are turning out a car every 20 minutes. Think of what weighing the output would mean to this business alone. I venture to say a reduction in the output of three to four cars per day would be the result. Would it pay or is there not some other way in which the intake and output of this plant can be taken care of which will give the same results without clogging the wheels of progress? Yes, there is, and I will endeavor to out-

line it. Take, for example, an order is placed for 1,000 standard 30-ton box cars; the bill of material incorporating all items entering into the construction of these cars is sent to me by the master car builder. This statement is checked and marked, and all items other than what we manufacture ourselves, such as wheels, castings, etc., are made on a special requisition placed with the general purchasing agent. The original bill of material is then sent to my storeman in charge of business in the freight car erecting shop, and is there posted in a special receiving book, which is kept for the purpose; it is then returned to the general store for filing. When the material starts coming in (you may have material coming in on several orders of freight cars at the same time) it is weighed, checked and compared with the tallies which accompany all shipments, whether they are received in cars or by city teams. When all material is in the lines opposite each item bear a tick mark or O. K. Now when it is decided to start building this order, the number of cars turned out each night is made up by my man and compared with the car foreman's record, and certain material, such as Westinghouse air brake material, roofs, truck bolsters, springs and iron are then covered by an order from the car foreman to my storeman, who posts them in his output book and forwards them to the general store, to be sent along with the disbursements to all other shops, and are delivered to the office to be charged up to the proper equipment account. This same system of getting at the intake and output of the shop applies to new coaches, sleepers, diners and to new engines.

CENTER OF GRAVITY OF A LOCOMOTIVE.—SIMPLE METHOD OF DETERMINING.

BY G. R. HENDERSON.

[We have recently received several requests to present a description of a simple method of determining the center of gravity of a locomotive. The following article is reprinted from page 319 of the October, 1899, issue of this journal and describes a very simple and practical method.]

The determination of the center of gravity of locomotives is a laborious task when computed mathematically, because in order to be accurate the weight and location of the center of gravity of each and every piece should be ascertained and their moments above the rail figured out, but the labor being so great, assumptions are made which affect more or less the final figures. It occurred to the writer that a practical method could be applied, and the following was therefore evolved:

Suppose that we have a body of symmetrical cross section, the weight of which is known. If this body be tipped slightly, so that one of the edges upon which it stands is lower than the other, the center of gravity will be displaced laterally. If this body rests upon supports at the two lower edges only, then the lower support will sustain more weight than the higher one, due to the lateral displacement of the center of gravity, and if the angle is such that the center of gravity be vertically over the lower edge, the total weight will come on this edge, and the body will be in unstable equilibrium. Thus, in Fig. 1, the whole weight will come upon the support B, but in Fig. 2 a portion will rest upon A and another portion upon B, but the sum of these two will be equal to the total weight. Let the weight of a symmetrical body be represented by W, the load on each support by Pa and Pb, respectively; then Pa plus Pb equals W. Let also the horizontal distance between the supports be represented by h and the vertical difference by v; also the distance measured horizontally between the support B and a vertical dropped through the center of gravity be represented by x. Now, by equal moments $Pa \times h$ equals $W \times x$ and

$$x = \frac{Pa \times h}{W}.$$

As the body is symmetrical, the center of gravity must be in the central axis c-d and at the intersection with the vertical through y, at a distance x from B, or at O. This may be laid off graphically, or it may be calculated by similar triangles.

This principle was practically applied to a locomotive, as follows: The engine was first carefully weighed on the track scales, with a certain height of water, etc., and was backed off the scales. The rail was then removed from the narrow side of the scale platform and blocks laid close together, like ties, from the outer frame to the fixed or dead rail support, care being taken to see that the portion of the scale under these blocks was entirely free. A rail was laid to gauge on these blocks and a slope prepared at one end. All was now ready, and, the beam being balanced, the water was brought to the same level as before in the boiler and the engine run upon the new track, and the load upon the lower rail weighed. While the engine is upon the scales a level should be run from rail to rail to determine the exact difference of level for use in making the calculations. Of course, there is a slight error, due to shifting of the water sidewise in the boiler, which tends to exaggerate the result. The frames should be blocked over the boxes, so that the boiler will stand relatively to the wheels, the same as on level track.

If care be taken, accurate results may be obtained, as with the small elevation of about 7½ ins. an increase in weight of 25,000 lbs. on the lower side of the engine was shown by the

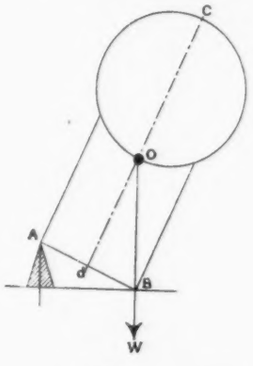


Fig. 1.

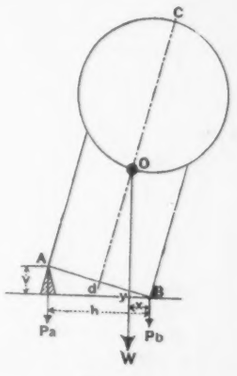


Fig. 2.

scales, the total weight of the locomotive being about 140,000 lbs.

[The following example of an application of the above method is taken from page 19 of Mr. Henderson's book on "Locomotive Operation," published in 1904. With a rail elevation of 7⅝ ins., the scale beams indicated 95,500 lbs. (Pb) on the lower rail and a measure of 58¼ ins. between points of rail contact (A and B) and 29½ ins. from the center line of the engine (c-d) to the lower rail contact. Now, if W = total weight and Pb = that on lower rail, while Pa is that on the higher rail, we must have $W = Pa + Pb$, and $Pa = W - Pb$, or $141{,}000 - 95{,}500 = 45{,}500$ lbs. So, by equating the moments, we find $Pa \times 58\frac{1}{4} = W \times x$, and

$$x = \frac{Pa \times 58\frac{1}{4}}{W} = \frac{45{,}500 \times 58\frac{1}{4}}{141{,}000} = 18.8 \text{ ins.}$$

In order to determine f (distance between the intersection of line c-d and line oW on line A-B) accurately (which is necessary), we must figure $f = 29\frac{1}{2} - 18.8$; sec e, e being the angle of inclination (d o W) from the vertical. But tan $e = \frac{7.62}{58.25} = .1325$, indicating that angle $e = 7° 33'$, and the secant of 7° 33′, or sec e = 1.0087, therefore $f = 29.5 - 1.0087 \times 18.8 = 10.5$ ins., and as $f = h \tan e$, we have

$$h = \frac{f}{\tan e} = \frac{10.5}{.1325} = 79.25 \text{ ins.,}$$

which is the height of the center of gravity above the rail.]

SHEET METAL COVERED WINDOWS are finding favor with insurance underwriters, as statistics show that 31 per cent. of the 80,000 buildings consumed by fire in 1905 were ignited by burning buildings adjoining.—*Iron Age.*

THE MATHEMATICAL ANALYSIS OF THE WALSCHAERT VALVE GEAR.

By Edward L. Coster,
Assoc. Am. Soc. M. E.

"The motion of a valve controlled by the Walschaert gear can be represented in a general way by Zeuner's diagrams, but the discrepancy between the results from such diagrams and the actual valve-motion is too large to allow us to use the diagrams even for a preliminary design. The general conception, however, is a very important matter,"[1] and is as follows:

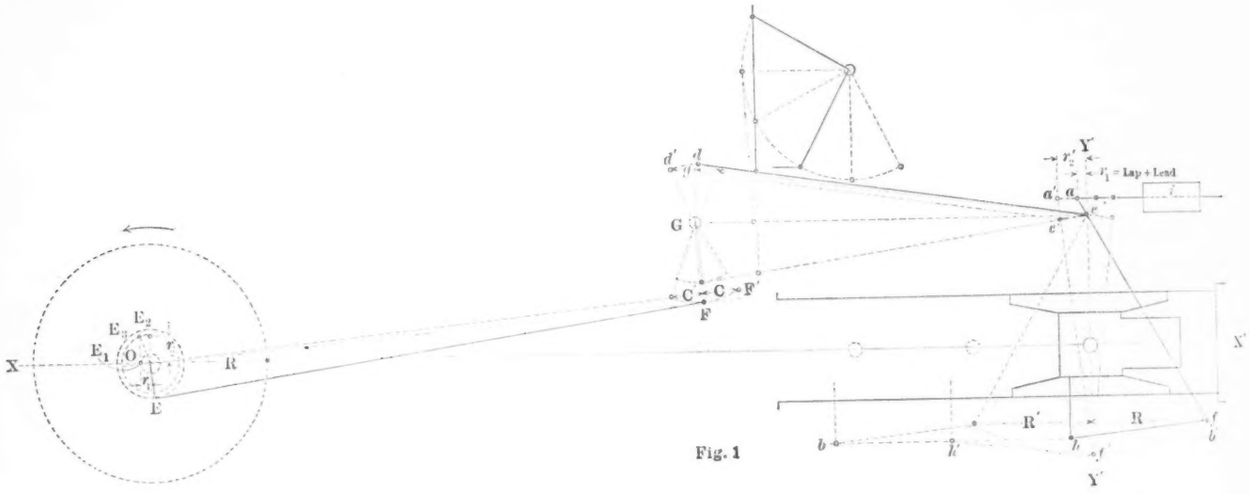


Fig. 1

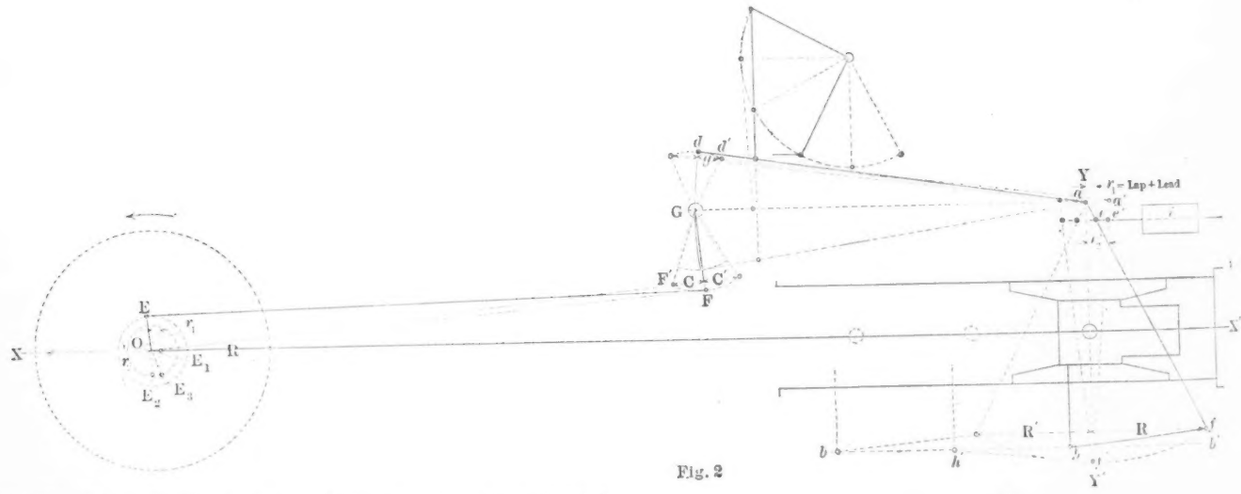


Fig. 2

In the above diagrams the combining lever, a f, is divided into two portions, a e = 2 in. and e f = 24 in.; the link arm G F = 8 in.; the extreme distance of the block pin from the link trunnion d G = 6 in.; the eccentricity of the eccentric O E = 3.5 in., and the crank radius R = 12 in.

These dimensions, although differing considerably from those of American locomotive practice, have been selected because, by their exaggeration of certain of the proportions of actual Walschaert valve motions, they render the drawings clearer than would otherwise be the case.

With the outside admission valve gear Fig. 1, the fulcrum of the combining lever is at e, and assuming this point to be stationary (i. e., disregarding the minute vertical motion of e caused by the rectilineal path of a, enforced by the valve stem guide i)[2], if the union link, h f, is made to vibrate through equal angles above and below the horizontal line b b', it is evident that R' = R = the crank radius, and the maximum valve displacement from mid-position due to the crosshead; or the radius, r_1, of an eccentric O E_1, which with 90° angular advance will, if connected directly to the valve, give the latter the same movement that it would derive from the crosshead alone, provided the crosshead motion was harmonic, is given by the proportion:

$$r_1 : a\,e :: R : e\,f, \text{ (sim. rt. triangles)}$$

$$\therefore r_1 = \frac{a\,e}{e\,f} R \quad \ldots\ldots (1)$$

$$= \frac{2}{24} \times 12 = 1 \text{ in.}$$

$$\text{Conversely, } a\,e = \frac{r_1}{R} e\,f = \frac{1}{12} \times 24 = 2 \text{ in.}$$

For the inside admission gear Fig. 2, the fulcrum of the combining lever is at a, and with the preceding assumptions, we have:

$$r_1 : a\,e :: R : a\,f,$$

$$\therefore r_1 = \frac{a\,e}{a\,f} R \quad \ldots\ldots (2)$$

$$= \frac{2}{26} \times 12 = 0.923 \text{ in.}$$

$$\text{Conversely, } a\,e = \frac{r_1}{R} a\,f = \frac{0.923}{12} \times 26 = 2 \text{ in.}$$

In this case, to obtain a maximum valve displacement r_1 = 1 in., we must make

$$a\,e = \frac{1}{12} \times 26 = 2.167 \text{ in.}$$

$$\text{whence, } r_1 = \frac{2.167}{26} \times 12 = 1 \text{ in., as required.}$$

[1] Peabody's "Valve Gears for Steam Engines," p. 139.

[2] In Fig. 1, if the angle a e Y = 30° (it should never exceed this value), then, as the combining lever swings from the perpendicular to either of the extreme positions, the fulcrum, e, rises vertically a distance ea vrs. sin. a e Y = 2 × 0.13397 = 0.27 in.; while in Fig. 2, an equal angular displacement of the lever from mid-position causes the fulcrum, a, to fall the same inappreciable amount.

From the foregoing it follows that assuming the motion of the crosshead to be harmonic, and ignoring the very slight inaccuracy resulting from the combined effect of the vertical movement of the fulcrum of the combining lever and the angular vibration of the union link, then with outside admission valve gear, at any crank angle, θ, the displacement of the valve from its central position, due to the crosshead alone, is

$$e_1 = r_1 \cos\theta = \frac{a\,e}{e\,f} R \cos\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

while for inside admission gear

$$e_1 = r_1 \cos\theta = \frac{a\,e}{a\,f} R \cos\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

In both of the above diagrams, when the crank-pin is at either dead point, the eccentric O E, and the link arm G F, are perpendicular to the center line O F, and disregarding the small discordance caused by the obliquity of the eccentric rod in conjunction with the vertical motion of the link pin F, then c′ = c = the eccentricity O E; and assuming the link block to be stationary in the link (i. e., ignoring the block slip), we have:

$$g : d'G :: e : GF', \text{ (sim. rt. triangles)}$$

whence, by substitution,

$$g : dG :: OE : GF,$$
$$\therefore g = OE \frac{dG}{GF}.$$

"With the limited amount it is advisable to allow in raising and lowering the link block in reversing the motion, we can without practical error consider the half-movement of the link block, d, to be the same as that of the points e"[3] and a, in Figs. 1 and 2, respectively; hence for any grade,[4] d G, of the link, the half-travel of the combining lever fulcrum, viz.:

$$e\,e' \text{ or } a\,a', = OE \frac{dG}{GF}.$$

Consequently, if we eliminate the effect of the crosshead motion upon the valve action (by uncoupling the connecting rod and blocking the crosshead at half stroke), and take d G equal to the full-gear distance of the block pin from the link trunnion, it is evident that with the outside admission valve gear Fig. 1, the maximum valve displacement from mid-position due to the eccentric O E; or the radius, r_2, of an equivalent eccentric O E_2, which with zero angular advance will, if connected directly to the valve, give the latter the same movement that it derives from the actual eccentric through the medium of the combining lever and link, is given by the proportion:

$$r_2 : a'f' :: ee' : e'f', \text{ (sim. rt. triangles)}[5]$$

which by substitution becomes,

$$r_2 : af :: OE \frac{dG}{GF} : ef,$$
$$\therefore r_2 = OE \frac{dG}{GF} \times \frac{af}{ef} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$
$$= 3.5 \times \frac{6}{8} \times \frac{26}{24} = 2.84 \text{ in.}$$

$$\text{Conversely, } OE = \frac{r_2}{\frac{dG}{GF} \times \frac{af}{ef}} = r_2 \times \frac{GF}{dG} \times \frac{ef}{af} = 2.84 \times \frac{8}{6} \times \frac{24}{26} = 3.5 \text{ in}$$

For the inside admission gear Fig. 2,

$$r_2 : e'f' :: aa' : a'f',$$

and by substitution,

$$r_2 : ef :: OE \frac{dG}{GF} : af,$$
$$\therefore r_2 = OE \frac{dG}{GF} \times \frac{ef}{af} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$
$$= 3.5 \times \frac{6}{8} \times \frac{24}{26} = 2.423 \text{ in.}$$

$$\text{Conversely, } OE = r_2 \times \frac{GF}{dG} \times \frac{af}{ef} = 2.423 \times \frac{8}{6} \times \frac{26}{24} = 3.5 \text{ in}$$

In this case, to obtain a maximum valve displacement $r_2 = 2.84$ in., we must make

$$OE = 2.84 \times \frac{8}{6} \times \frac{26}{24} = 4.102 \text{ in.};$$

$$\text{whence, } r_2 = 4.102 \times \frac{6}{8} \times \frac{24}{26} = 2.84 \text{ in., as required.}$$

From the preceding analysis it follows that disregarding the irregularities produced by the block slip, and the angularities of the eccentric rod, link arm and radius bar, then with outside admission valve gear, for a given grade, d G, of the link, the displacement of the valve from its central position due to the eccentric O E, is

$$e_2 = r_2 \sin\theta = \left[OE \frac{dG}{GF} \times \frac{af}{ef} \right] \sin\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

and for inside admission gear,

$$e_2 = r_2 \sin\theta = \left[OE \frac{dG}{GF} \times \frac{ef}{af} \right] \sin\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Now, the entire displacement, e, of the valve at any crank angle is evidently the sum of the displacements of the two independent sources, namely, the crosshead and the eccentric; therefore, with outside admission valve gear, from equations 3 and 7 we have:

$$e = e_1 + e_2 = r_1 \cos\theta + r_2 \sin\theta = \frac{a\,e}{e\,f} R \cos\theta +$$
$$\left[OE \frac{dG}{GF} \times \frac{af}{ef} \right] \sin\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

while for inside admission gear, from equations 4 and 8 we obtain:

$$e = e_1 + e_2 = r_1 \cos\theta + r_2 \sin\theta = \frac{a\,e}{a\,f} R \cos\theta +$$
$$\left[OE \frac{dG}{GF} \times \frac{ef}{af} \right] \sin\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

and since r_1 and r_2 are constant for any grade of the link, r_1 and r_2 (i. e., the radii of the virtual eccentrics, O E_1, and O E_2, at 90° to each other) are the coördinates of the diameter of the valve circle in the Zeuner diagram, for that grade of the gear.

Thus, referring to the Zeuner diagram Fig. 3, it is evident that with the outside admission valve motion, Fig. 1, in full back gear, when the crank is at the front dead point A′, the centers of the equivalent eccentrics are at E_1 and E_2; hence at any crank angle, the actual displacement of the valve, derived from both sources, is the displacement due to the combined or resultant eccentric O E_3

$$= \sqrt{\overline{OE_1} + \overline{OE_2}} = \sqrt{r_1^2 + r_2^2}$$
$$= \sqrt{\left(\frac{ae}{ef} R\right)^2 + \left(OE \frac{dG}{GF} \times \frac{af}{ef}\right)^2} \quad \ldots\ldots \text{(equations 1 and 5)}$$
$$= \sqrt{\left(\frac{2}{24} \times 12\right)^2 + \left(3.5 \times \frac{6}{8} \times \frac{26}{24}\right)^2}$$
$$= \sqrt{1^2 + 2.84^2} = \sqrt{9.0656} = 3 \text{ in. (almost exactly);}$$

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[3] "Walschaert Valve Gear as applied to Large American Locomotives," p.p. 34-35; The American Locomotive Company, 1906.

[4] By the term "grade of link" is meant the position of the link block in the link, as at full-gear, half-gear, mid-gear, etc.

[5] Owing to the rectilineal paths of a, Fig. 1, and of e, Fig. 2, due to the valve stem guide 1, in both cases the fulcrum of the combining lever describes a line that is, with sufficient accuracy for present purposes, a right line perpendicular to Y Y′; hence the above proportions based upon the relations of the sides of similar triangles.

for which eccentric the investigation of the valve action during a complete revolution is obviously accomplished by means of the valve circles o b and o b″ in the usual manner.[6]

Also, since the radius and position of the eccentric O E_1, is constant for all grades of the link, while equation 5 indicates that the eccentricity, r_2, of O E_2, varies directly as the distance,

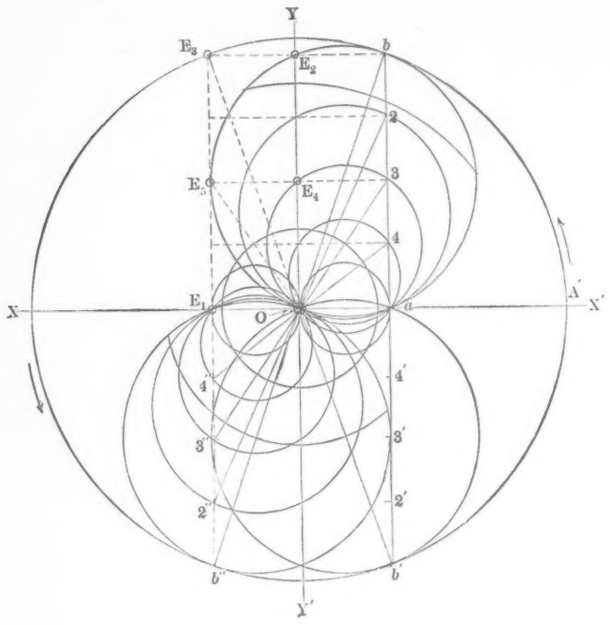

Fig. 3.

d G, of the block pin from the link trunnion, it follows that at half-gear the centers of the equivalent eccentrics are at E_1 and E_4; the resultant eccentric O E_5

$$= \sqrt{\left(\frac{2}{24} \times 12\right)^2 + \left(3.5 \times \frac{3}{8} \times \frac{26}{24}\right)^2}$$

$$= \sqrt{1^2 + 1.42^2} = \sqrt{3.0164} = 1.73 \text{ in. (very approximately)};$$

the analysis of the valve movement is made by the circles 0 3, 0 3″; and similarly for all other grades of the link from full backward to mid-gear. At the latter point, $r^2 = 0$, and for both directions of rotation, the valve displacements are given by the circles Oa, OE_1.

In the Zeuner diagram Fig. 4, for the inside admission valve motion, Fig. 2, when the crank is at the front dead point and the link in full back gear, the centers of the equivalent eccentrics are evidently at E_1 and E_2; the resultant eccentric O E_5

$$= \sqrt{\overline{O E_1}^2 + \overline{O E_2}^2} = \sqrt{r_1^2 + r_2^2}$$

$$= \sqrt{\left(\frac{a e}{a f} R\right)^2 + \left(O E \frac{d G}{G F} \times \frac{e f}{a f}\right)^2} \quad \text{(equations 2 and 6)}$$

$$= \sqrt{\left(\frac{2}{26} \times 12\right)^2 + \left(3.5 \times \frac{6}{8} \times \frac{24}{26}\right)^2}$$

$$= \sqrt{0.923^2 + 2.423^2} = \sqrt{6.7083} = 2.59 \text{ in. (almost exactly)};$$

and the valve action is represented by the valve circles o b, o b″, as before.

At half-gear, the equivalent eccentric centers are at E_1 and E_4; the resultant eccentric O E_5

$$= \sqrt{\left(\frac{2}{26} \times 12\right)^2 + \left(3.5 \times \frac{3}{8} \times \frac{24}{26}\right)^2}$$

$$= \sqrt{0.923^2 + 1.211^2} = \sqrt{2.316} = 1.52 \text{ in. (very approximately)};$$

the valve displacements are obtained from the circles 0 3, 0 3″; and likewise for all back gear positions of the link block.

It is therefore apparent that the motion imparted by the Walschaert gear to both outside and inside admission valves can be approximately represented by Zeuner's valve diagrams similar to those used for the Gooch link motion, or for a shifting eccentric with constant lead. "As usually constructed," the Walschaert "gear does not give harmonic motion to the valve, for the motion of the crosshead of the engine with the usual proportions of locomotives has considerable irregularity on account of the angularity of the connecting rod; also some irregularity is introduced by the combining lever a f. Consequently such" diagrams as Figs. 3 and 4, "can be of use only in roughly blocking out a gear. The real action

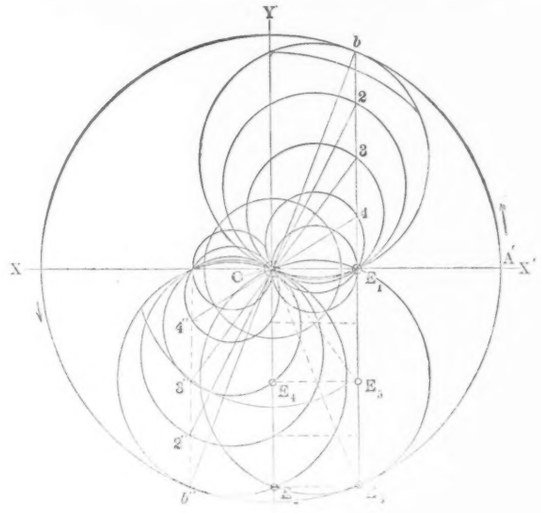

Fig. 4.

of the gear can be determined either by constructing diagrams similar to" Figs. 1 and 2 "on as large a scale as convenient, or by aid of a model. A combination of the two methods, similar to the skeleton model for link motions, may be found convenient for this purpose. Since part of the motion of the valve is derived from the crosshead, the adjustment of the gear to give equal cut-off will generally be easier than for a link motion."[7]

QUALIFICATIONS OF AN ENGINEER.—It is my constant observation of four engineering works, employing about 20,000 men, that engineers reach the limit of their usefulness from defects of character, rather than from want of technical attainments. Our greatest difficulty is to find courage, candor, imagination, large vision and high ambition. I do not know which of these qualities is most often lacking, or which is most essential. The lack of courage and candor comes most often to my notice, but the lack of imagination and of broad outlook produces the most serious disasters. All of these things an engineer must have if he is to go far, and all of these any citizen must have if he is to go far in the work of life. Our scheme of education will be radically defective if it does not provide for the development of courage and candor, of imagination and broad vision and high ambition.—*Col. H. G. Prout.*

THE STEEL TIE.—Take any period of five years, and the interstate reports show that tie renewals are from two to two and a half times the cost of the renewal of rails. On the assumption that the steel tie can be produced at the same price per pound as the steel rail and that the life of the steel tie will be one and a half times that of the steel rail, the cost of tie renewal would be about equal to that of rail renewal. Experience in Europe and observation from our own experience here indicate that a longer life will be obtained. The possible reduction of cost of tie renewals to the same cost as rail renewals shows the great economy obtainable from the use of steel ties. A portion of this reduction is due to being able to sell the old tie for scrap for 40 to 50 per cent. of its original cost.—*Mr. H. T. Porter, before the Railway Club of Pittsburgh.*

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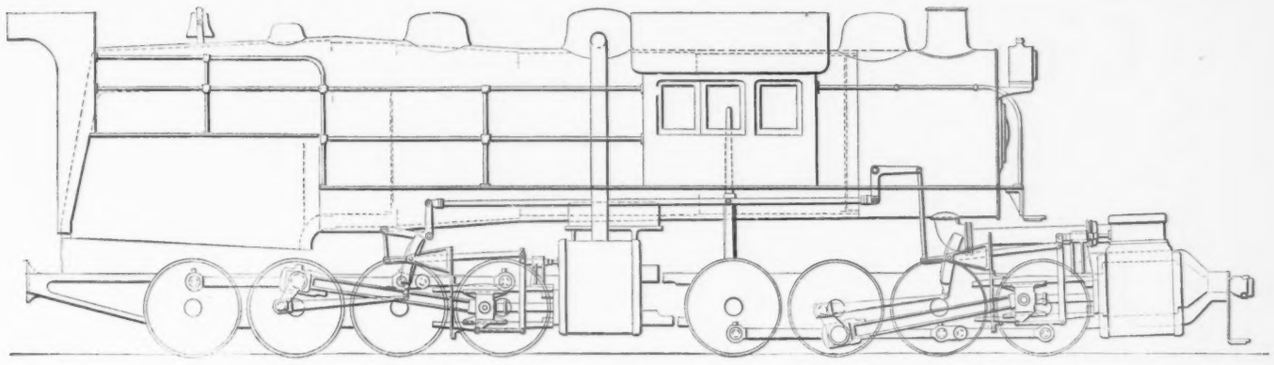
[6]For a full explanation of the construction and use of the Zeuner diagram, refer to Peabody's "Valve Gears for Steam Engines;" also to Henderson's "Locomotive Operation," p.p 86-97.

[7]Peabody's "Valve Gears for Steam Engines," p. 85.



MALLET ARTICULATED COMPOUND LOCOMOTIVE 0—8—8—0 TYPE, ERIE R. R.

HEAVIEST LOCOMOTIVE IN THE WORLD.

ERIE RAILROAD.

The American Locomotive Company are preparing designs for three Mallet articulated compound locomotives for the Erie Railroad, of which the accompanying illustration is a preliminary outline diagram. These locomotives will weigh approximately 410,000 lbs., all on drivers, and hence will be by far the heaviest locomotives in the world, exceeding the previous Mallet compounds built in this country in all respects, as can be seen by reference to the accompanying table giving the comparative dimensions with the ones built for the Great Northern Railway by the Baldwin Locomotive Works, which were illustrated in this journal in October, 1906, page 371, and the Baltimore & Ohio locomotives built by the American Locomotive Company, which were illustrated in this journal in 1904 and 1905.

Road	Balt. & Ohio.	Great North.	Erie.
Builder	American.	Baldwin.	American.
Wheels	0—6—6—0	2—6—6—2	0—8—8—0
Total weight	334,500 lbs.	355,000 lbs.	410,000 lbs. est.
Weight on drivers	334,500 lbs.	316,000 lbs.	410,000 lbs. est.
Size of cylinders	20&32x32 in.	21½&33x32 in.	25&39x28 in.
Diameter of drivers	56 in.	55 in.	51 in.
Tractive effort	71,500 lbs.	71,600 lbs.	98,000 lbs.
Steam pressure	235 lbs.	200 lbs.	215 lbs.
Total wheel base	30 ft. 8 in.	44 ft. 10 in.	39 ft. 2 in.
Driv. wheel base rigid.	10 ft.	10 ft.	14 ft. 3 in.
Total heating surface	5,585 sq. ft.	5,658 sq. ft.	6,108 sq. ft.
Grate area	72.2 sq. ft.	78 sq. ft.	100 sq. ft.

The preliminary announcement of these locomotives indicates that they will have a number of very interesting features. It can be seen that there will be 16 drivers, or four pairs on each of the two groups; that the boiler will have 21-ft. flues and a 4-ft. combustion chamber, which makes the boiler shell probably the longest ever built for a locomotive; the total heating surface will be over 6,000 sq. ft., and the grate will have an area of 100 sq. ft.; the low-pressure cylinders will be 39 ins. in diameter and the high-pressure 25 ins., the stroke in both being 28 in. and the tractive effort will be 98,000 lbs.

As the design of these engines is in a preliminary stage, very little can be given as regards details at this time, but we hope in a later number to illustrate all the interesting features of these monster machines. The general dimensions and estimated weights available are as follows:

MALLET ARTICULATED COMPOUND LOCOMOTIVE 0—8—8—0 TYPE.

ERIE RAILROAD.

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Freight
Fuel	Bit. coal
Tractive effort	98,000 lbs.
Weight in working order, estimated	410,000 lbs.
Weight on drivers, estimated	410,000 lbs.
Weight of engine and tender in working order, estimated	573,000 lbs.
Wheel base, driving	14 ft. 3 in.
Wheel base, total	39 ft. 2 in.
Wheel base, engine and tender	72 ft. 2 in.

RATIOS.

Weight on drivers ÷ tractive effort	4.18
Tractive effort × diam. drivers ÷ heating surface	820
Total heating surface ÷ grate area	61
Firebox heating surface ÷ total heating surface, %	5.7
Weight on drivers ÷ total heating surface	67

CYLINDERS.

Kind	Compound
Number	4
Diameter and stroke	25 & 39x28 in.

VALVES.

Kind	H. P. Piston
Kind	L. P. Bal. Slide

WHEELS.

Driving, diameter over tires	51 in.
Driving, thickness of tires	3½ in.

BOILER.

Style	Conical
Working pressure	215 lbs.
Outside diameter of first ring	84 in.
Firebox, length and width	126 x 114 in.
Firebox, combustion chamber, length	48 in.
Tubes, number and outside diameter	468 2¼ in.
Tubes, length	21 ft.
Heating surface, tubes	5,760 sq. ft.
Heating surface, firebox	348 sq. ft.
Heating surface, total	6,108 sq. ft.
Grate area	100 sq. ft.

TENDER.

Water capacity	8,500 gals.
Coal capacity	16 tons

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION.

The fifth annual convention of this association was held at "The Breslin," New York, on October 9th and 10th, and was one of the best, from the standpoint of attendance, ever held by the association, which now includes about 80 of the most important machine tool builders of the country. Of these 15 applied for membership at this meeting, indicating that the benefits possible by identification with the association are being more generally realized.

Mr. E. P. Bullard, Jr., Bridgeport, Conn., presented a paper on the subject of "apprenticeship," which was enthusiastically received. This paper served as a report of the committee appointed at a previous meeting to investigate this subject and recommend a standard system to be followed throughout the country offering inducements to young men to learn the machinist trade. The committee was continued, and it is expected that definite action, in the way of adoption of the standard suggested, will be taken at the next meeting.

Mr. J. M. Gunn, New York, delivered an address on the subject of "Costs," in which he pointed out that the association could accomplish much good for its members by adopting a uniform system of determining costs. He said that it did not make so much difference which system was adopted as long as it was uniform. A committee was appointed to investigate the subject and report at the next meeting.

The entertainment features consisted of a luncheon at the Hotel Imperial, tendered by the Hill Publishing Company, and a boat ride to West Point, tendered by the Industrial Press.

The following officers were elected for the ensuing year: President, E. M. Woodward, Worcester, Mass.; 1st vice-president, Wm. Lodge, Cincinnati, O.; 2d vice-president, F. E. Reed, Worcester, Mass.; treasurer, W. P. Davis, Rochester, N. Y., and secretary, P. E. Montanus, Springfield, O.

(Established 1832).

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Contributions.—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase of construction.*

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There seems to be a marked tendency to abolish the system of special apprenticeship and to have the college graduate start to work under the same conditions as the ordinary apprentice. This is as it should be. The practice of placing special apprentices in the shop tends to discourage not only the regular apprentices but the mechanics as well, since it is practically understood that the special apprentice will be pushed along and promoted over their heads. In a great many instances the "special" has been given a better class of work, which, however, could usually be handled almost equally as well by the regular apprentice, who would, undoubtedly, be greatly encouraged if allowed to do such work as a reward for careful and conscientious effort. The fact that the "special" has been allowed to do so much of this work has also been a bad thing for him, as the time spent in the shop is so short that all of it should be devoted to doing and studying the regular operations and in getting into close touch with the men, so that he will not only be in a position to know how to handle them to get the best results, in event of his being promoted, but will also know how to properly issue instructions concerning work to be done.

The personnel of the average railroad drawing room force is continually changing, and much time is usually lost in instructing new men as to the methods in use in each particular drawing room. On one road the mechanical engineer and chief draftsman, out of pure self-defense, got up an eight-page blue-print pamphlet, about 9 by 12 ins. in size, giving instructions as to the standard sizes of drawings, rules as to dimensioning, scales, lettering, methods of projecting, cross sectioning, information as to titles, pattern numbers and shop cards, drawing numbers, references on the drawings, revisions, and builders' prints. Not only did these result in a considerable saving in time in the drawing room, but they made it possible to turn out more uniform drawings, thus making it easier for the men in the shop to follow them and use them properly.

A novel method of checking the efficiency of employees, which is made possible by the use of electrically driven machinery, has been introduced in the works of the Firth-Sterling Company. It consists of placing in a convenient location for observation a recording ammeter, arranged to be connected in circuit with any machine whenever desired. Previous tests have determined approximately the current required for a given class of work, so that the record of the ammeter indicates whether or not the machine is working up to its capacity and the time it stands idle. In another works where this was tried it was found that, aside from the question of the efficiency of employees, the curves obtained afforded a means of locating weak spots in setting the work in place and handling it to and from the the machine. Very often the actual time the machine was in operation was a surprisingly small percentage of the working day, and by following up instances of this kind it was possible to considerably improve the output.

The reasons for the widespread popularity of the Walschaert valve gear on American Railroads were put into a nutshell by Mr. A. W. Gibbs, whose remarks are quoted in full on the opposite page, at the September meeting of the New York Railroad Club when he stated that the advantages of this gear, as he saw it, were entirely mechanical. The Pennsylvania Railroad, which has long been noted for its carefulness in taking up any radical departures in locomotive design, now has over 400 locomotives, both freight and passenger, equipped with the Walschaert valve gear, this being more than any other company in the country has at present. In enumerating the features of the design, which has led the company to equip this large number of engines on a comparatively short trial, Mr. Gibbs makes prominent the following features: First, that it was found that the valves operated by the Walschaert valve gear remain square a much longer time

than with the Stephenson motion. This one feature goes far to off-set the probably better general steam distribution obtained by means of the latter valve motion, for, of course, if the valves do not remain as they were originally set the economy to be derived from that setting is lost. Second, the opportunity given to properly and rationally brace and stiffen the main frames by the removal of the valve motion parts from between the frames; and third, the accessibility of the motion for inspection and repair, which naturally results in its being maintained in a better condition.

The only argument advanced in the discussion as opposed to the gear was the fact that it gives a constant lead for all points of cut-off, and hence is not as flexible, that is, will not give as good steam distribution under different and varied speed conditions. The constant lead is an inherent feature of the gear and theoretically it is a very distinct disadvantage when applied to a locomotive which is to be operated under conditions requiring any considerable range of speed; but practically, the fact mentioned by Mr. Gibbs, which is not at all unusual, that with the Stephenson gear on large engines, the engineer is often afraid to move the reverse lever and place it in an economical position for fear of being thrown through the front window, considerably lessens the effectiveness of this argument. It is stated that thus far the Pennsylvania Railroad has not found the tractive effort of these locomotives to be less than those of the Stephenson link motion, although complete tests have not yet been finished.

The primary cause of the introduction of the Walschaert valve gear in this country is the big locomotive and the reasons for its adoption are purely mechanical.

In a communication on another page Mr. Coleman has called attention to the fact that as at least 99 per cent. of the actual work in repairing or building locomotives is done by the ordinary mechanic, it is of prime importance if the quality of the shop output is to be improved and the amount increased that the individual mechanic be carefully studied in order to improve his condition and spur him on to greater effort. Very often an ambitious mechanic becomes discouraged because, after he has gotten up some device or idea for improving the production, a superior officer is given the entire credit for it. This not only discourages the man from trying to make additional improvements, but it indirectly works against the officers in charge, since they lose the co-operation of the men in improving conditions. The shop superintendent who makes the best record is the one who sees that credit is given where it is due, and thus spurs the men on to greater efforts.

An interesting plan which was observed by Mr. G. M. Basford while visiting the works of Mr. A. Borsig, at Tegel, Germany, was described on page 319 of our September, 1905, issue, and is as follows: "In every shop a letter-box is put in a conspicuous place, and the men are asked to submit in writing suggestions for improving the work of the plant or decreasing its cost. This is not original at Tegel, it is in use in many shops, but by close attention from Mr. Dorn, the manager of the works, fifty good suggestions have been put into effect in about a year and a half. The suggestions are usually accompanied by sketches, and sometimes by very good drawings. The subjects are gone into very carefully, and those having sufficient merit are put into effect, suitable records being made in a book. Employees receive cash prizes for their suggestions, the amounts varying from very little up to about $100. More than this would be paid for a specially good thing. This works very well in Germany, where the men are much steadier than in some newer countries. It should work even better in the United States, and it seems a little strange that railroads do not carry out an idea of this kind." Even if it was not thought practical to give cash prizes, think of the encouragement the men would receive if the superintendent of motive power should send them a personal letter expressing appreciation of their work, or if when he visited the shop he should look the man up and give him a good, hearty handshake and thank him for what he had done.

1907 CONVENTIONS OF THE M. M. AND M. C. B. ASSOCIATION.

At the meeting of the officers and executive committees of the American Railway Master Mechanics' Association, Master Car Builders' Association and the Supply Mens' Association to decide on the place of meeting for the conventions to be held in June, 1907, which took place in New York on October 29, it was unanimously decided to again meet at Atlantic City. The steel pier, which has been considerably enlarged since last year, will be used for the exhibits, and the regular meetings will be held in the "Sun Parlor," as before. The opening sessions only will be held in the ball room on the steel pier. The headquarters of the convention, however, will be at the Marlborough-Blenheim, and the balls and evening entertainments will be held in the large ball room of the new million-dollar pier, which is now approaching completion and is located near the headquarters.

Special arrangements are to be made in the location of the exhibits, so that nothing of a noisy nature will be in the vicinity of the meeting hall. The general appearance of the exhibit booths and their arrangements is to be given more careful attention and, in fact, all the unpleasant or undesirable features which developed during the previous experience will be eliminated as far as possible.

THE WALSCHAERT VALVE GEAR ON THE PENNSYLVANIA RAILROAD.

At the September meeting of the New York Railroad Club, in discussing Mr. Kennedy's paper on "The Walschaerts Valve Gear as Applied to Locomotives," Mr. A. W. Gibbs, general superintendent of motive power of the Pennsylvania Lines east of Pittsburgh and Erie, spoke as follows concerning the reasons for the introduction of this gear on that railroad and the results so far attained:

"The Pennsylvania Railroad having introduced the Walschaert valve gear on a rather large scale, it would not be amiss to consider the conditions that led to the change from Stephenson link heretofore used.

"In the older types of locomotives, with which we are all familiar—more particularly in the eight-wheel type—where fairly long and straight eccentric rods could easily be employed, the service rendered by the Stephenson link motion was entirely satisfactory. The steam distribution was then very good; the wear and tear of parts small; the handling of the reverse lever easy, and all parts of the motion were readily accessible.

"When we departed from the simple eight-wheel type and introduced additional driving wheels, filling up the space between them with spring rigging, brake shoes and other devices, the situation at once became more complicated. We were then confronted with the necessity of either using bent eccentric rods, in order to get adequate length and at the same time clear the axle, or to use very short rods and various forms of extension by which to finally reach the valve. The increasing size of axles, and the greater throw of eccentrics, required a very large sheave, and with the lateral play that accumulates in the boxes and with the shortness of the rods, the binding effect of the straps on the eccentrics becomes a very serious matter; and I think all of us who have had experience with this type of equipment realize that not only is there very rapid wear of the eccentrics themselves, but have also experienced difficulties from the breakage of the supports for hanging the links. The inaccessibility of the motion in this same type of locomotive is such that the attention which it receives is by no means equal to that formerly given, and the inertia due to the increasing weight of the parts seems to be a very potent factor in shortening the life of the motion as a whole. In other words, when put right, it will not stay put.

"It has long seemed to me that there is a striking analogy between our shifting link motion and the Prony brake. The four straps, with their rods, each form a brake, and the pull

of these four brakes is all transmitted to the lift shaft and thence to the reverse lever. The tendency is for the forward ends of these four brakes to revolve with the axle, so that, granting that the balancing springs were right for an engine in the standing position, it was entirely inadequate for the same engine while running. We all know of engines which the runners are afraid to handle while running, for fear of being pulled through the front of the cab, with the result that the reverse lever once set in its position on the quadrant remains in that position, up hill and down dale, to the next stop and start, and we all know of the cut seats from drifting with the lever in that position. Such refinements as closer graduation of the quadrants to enable the locomotives to be run at the most economical cut-off then become superfluous under such circumstances when the enginemen dare not move the lever to put it in such economical position.

"The reason for becoming dissatisfied with the Stephenson link motion, therefore, as I see it, was purely mechanical; and had we continued to stick to the older types of locomotives our attention would probably not have been called to the necessity for a change.

"The history of the use of the Walschaert valve gear on the Pennsylvania Railroad dates from the importation of the DeGlehn locomotive, which was constructed at the Belfort (France) works of the Societe Alsacienne de Constructions Mecaniques, and exibited and tested at the Louisianna Purchase Exposition in St. Louis in 1904, and has since been doing excellent work on the road. Not the least of the considerations which led to this importation was that we might learn from it many details which could advantageously be applied to our own equipment and, even granting the engine as a whole might not suit our conditions, that, nevertheless, the value of the lessons to be learned from it would fully justify the expense of the experiment, and I am glad to say that these expectations have been fully realized.

"This DeGlehn locomotive, as you probably know, is of the balanced compound type, with independent valve motions for the high and low pressure engines, being operated from one screw shaft so arranged that the screw actuating the low-pressure levers can be disengaged at will, so that in practice the low-pressure cut-off is usually placed so as to give from 65 to 70 per cent. cut-off, further adjustments being made in the high-pressure cut-offs.

"As compared with our own valve motions, that of the DeGlehn locomotive is everywhere exceedingly light. Some of the details, such as the links, while beautifully designed, are expensive to construct and, unless a high grade of workmanship is obtained, are liable to give trouble.

"Among the features very noticeable in the Walschaert gear of this DeGlehn locomotive is the care that has been taken to get all the working parts in one vertical plane. On the high-pressure engine, which is outside of the frames, it has been practicable to do this by offsetting the high-pressure valve chests and still keep them within our clearance limits. In the low-pressure engine the motion is taken by one eccentric for each cylinder, and in this case a rocker with double bearings is employed to reach the proper valve center. This eccentric strap appears to us to be insignificant in its bearing surface—merely 2 ins. long, lined with white metal. Nevertheless, its wear has been very satisfactory, indicating how small is the work to be performed. The entire adjustment of this motion is at a small crosshead which guides the valve stem, and all pin fits throughout are straight ones.

"Our first application of Walschaert valve gear, next succeeding that on the DeGlehn locomotive, was to a small trial lot of ten Consolidation type locomotives—part of a large order then under construction that had been placed early in 1905—which ten engines were distributed over all grand divisions of the road, with the hope that we might have ample time to test them before deciding what type of motion should be applied to the next order of about 160 Consolidation locomotives. There were such delays in the completion of this small lot of ten locomotives with the Walschaert gear that in a little over one month after they were turned out we had to decide the question, but by that time the reports received from the road people were so favorable that we did not hesitate to continue the application of the Walschaert motion.

"We have since applied this Walschaert valve gear to our Atlantic type locomotives, so that at the present time we have 352 locomotives so equipped on the lines east of Pittsburgh, and on the lines west some fifty-five more, a total of more than four hundred locomotives.

"Being particularly anxious to retain the principle that this Walschaert gear should be in one vertical plane, we decided (for both the Consolidation and Atlantic types) that rather than to use rockers to actuate slide valves, we had better change to the piston valve offset to the limit of our clearances, and this has been done.

"It is too early as yet to express final opinion as to the wisdom of the change, as the locomotives have not been in service long enough to require heavy repairs.

So far as we have gone, however, particularly with freight locomotives, the opinion is entirely favorable, and while there are some valves out of adjustment, due to tampering with the adjusting nuts, it is noticeable that the lame engines are seldom among those equipped with the Walschaert gear.

"Preliminary experiments with the dynamometer car indicate that the drawbar pull is certainly no less than that of similar locomotives equipped with the Stephenson link motion and slide valves.

"Contrary to our expectations, no protest whatever came from the road when these Walschaert gear locomotives were introduced, the road people without exception placing high value on the accessibility of the gear.

"Indirectly, other benefits have followed the introduction of the Walschaert valve gear. The absence of the link motion very much facilitates attention to the driving boxes, and, for the same reason, it has been practicable to introduce strong bracing between the frames in order to lessen what has been one of our greatest sources of expense in locomotive maintenance, namely, frame breakage.

"Further than this I am not prepared to go, as dynamometer trials have not been completed, nor have any of these Consolidation locomotives with the Walschaert gear been placed on the locomotive testing plant.

"As a method of steam distribution, I am unable to see that the Walschaert gear differs much from the Stephenson link motion, further than that a gear which is square, and remains so, is to be preferred to one in which various sources of lost motion combine to render the actual distribution very different from that figured on the drawing board. The effect of the constant lead is not noticeable in the performance. In other words, the advantages of the Walschaert gear, as I see them at present, are purely mechanical. The breakages have been very few and were readily remedied; and, if the future history confirms the earlier showing, I believe that, from the transportation side, the locomotives with the Walschaert gear will be very popular, owing to absence of breakdowns on the road."

STATISTICS OF RAILWAYS IN THE UNITED STATES

The eighteenth annual report of the Interstate Commerce Commission for the year ending June 30, 1905, contains some very interesting figures on the statistics of railroads in the United States. It shows that the total single track mileage at that time was 218,101 miles, or over 4,000 miles more than the preceding year. The total mileage, including tracks of all kinds, was 306,796.74 miles, an increase of very nearly 10,000 miles, of which over 35 per cent. represents extension of yard track and sidings. The number of railway corporations for which mileage is included in the report was 2,167. The number of roads in the hands of receivers was 26, with a mileage of 795.82 miles.

The number of locomotives in service on June 30, 1905, was 48,357, an increase during the year of 1,614. The total number of

cars of all classes was 1,842,871, an increase of over 44,000. This was divided between passenger service cars numbering 40,713, freight cars, 1,731,409, and company service cars. These figures do not include cars owned by private commercial firms or corporations. The average number of locomotives per 1,000 miles of line was 223; the average number of cars, 8,494. The number of passenger miles per passenger locomotive was 2,048,558, an increase over the previous year of 100,174. The number of ton miles per freight locomotive was 6,690,700, an increase of 233,854.

The number of persons on the pay rolls of railroads in the United States on June 30, 1905, was 1,382,196, which is equivalent to an average of 637 employees per 100 miles of line, an increase of 26. The total number of railroad employees, disregarding a small number not assigned, were apportioned as follows: For general administration, 54,141; for the maintenance of way and structures, 448,370; for the maintenance of equipment, 281,000, and for conducting transportation, 595,456. The total amount of wages or salary paid to the employees during the year was $839,944,680.

The par value of the railway capitalization outstanding was $13,805,258,121, which is equivalent to a capitalization of $65,926 per mile. Of the total capital stock, 37.16 per cent. paid no dividends. The amount of dividends declared during the year was equivalent to 5.78 per cent. on a dividend-paying stock.

The number of passengers carried during the year was 738,834,667, being 23,414,985 more than during the previous year. The passenger mileage, or number of passengers carried one mile, was 23,800,149,436, the increase being nearly two billion. The ton mileage was 186,463,109,510, the increase being nearly twelve billion ton miles. The number of ton miles per mile of line was 861,396, indicating an increase in the density of freight traffic of 31,920 ton miles per mile of line. The average revenue per passenger per mile was 1.962 cents. The average revenue per ton mile of freight was 0.766 cents. The ratio of operating expenses to earnings was 66.78 per cent.

The gross earnings per mile of line averaged $9,598, of $292 more than the previous year. The operating expenses averaged $6,409 per mile of line, and the net earnings per mile were thus $3,189.

The total number of casualties to persons on the railways for the year was 95,711, of which 9,702 represented the number of persons killed. Of these, 1,990 were trainmen, 136 were switch tenders and switchmen, and 1,235 were other employees. The number of passengers killed during the year was 537, and 10,457 were injured; of these, 341 passengers were killed and 6,053 injured because of derailments and collisions. The total number of persons, other than employees and passengers, killed was 5,805; injured, 8,718. One passenger was killed for every 1,375,856 carried, and one was injured for every 70,655 carried. One passenger was killed for every 44,320,576 passenger miles, and one injured for every 2,276,002 passenger miles.

WHAT RAILROAD PASSENGERS GET FOR THEIR FARES.

An exhaustive pamphlet on passenger fares has been prepared by Slason Thompson, of Chicago, having special reference to the agitation for a two-cent maximum fare. Tables are submitted to show that the income from passengers alone does not come within $73,000,000 of meeting the expenses of the passenger service of the railroads of the country, while the combined revenue from passengers, mail and express exceeds the cost of operation by only $23,925,105.

Instead of a decrease in the cost of passenger traffic since 1893, the public demand for higher speed, additional trains, more conveniences, and greater safety, has actually advanced the expense beyond what it was when the Interstate Commerce Commission estimated it as 1.955 cents per passenger mile.

The safety, comfort and convenience of the traveling public continuously demand that railways expend liberal sums in putting their service on the most efficient and safe basis. To do this, lines must be double-tracked, bridges and culverts must be strengthened, heavier rails laid, road beds remade, interlocking switches installed, block signals introduced, dangerous grade crossings abolished, and passenger cars must be stronger, better lighted, heated and ventilated.

As an instance of what the railways are doing to meet the public demand for safer and more expeditious passenger service, it may be mentioned that over $32,000,000 has been spent on track elevation in Chicago since 1893, and that before this great work is completed it will cost the roads centering there fully $30,000,000 more.

Compliance with such demands is more important than cheap fares, and yet it is proposed to make the instalment of these improvements more difficult, if not impracticable, by curtailing the income of the railways from the very service in whose interest the expenditures are most clamorously demanded.

What has been done in the matter of increasing the speed and frequency of passenger trains is illustrated by a summary prepared by officials of the Chicago & Northwestern Railway of the number and speed of the trains over the Wisconsin division of that line for the years 1890 and 1905. These show an increase in frequency of passenger facilities of from 25 to 133 per cent., and in average speed from 5 per cent. up to nearly 40 per cent. What is true of this one line in Wisconsin has been duplicated all over the United States, wherever conditions have invited additional transportation facilities.

Aside altogether from the indivisible expenditures involved in making the improvements partly enumerated above, where the cost cannot be apportioned between passenger and freight traffic, there has been a striking advance in the cost of the equipment, material and labor directly chargeable to the passenger service.

The following table shows the increased initial cost of the equipment employed in passenger service:

	1893 Average Cost.	1906 Average Cost.	Increase per cent.
Passenger locomotives	$9,800	$20,000	104
Passenger coaches	5,400	9,000	66
Mail cars	3,900	7,500	92
Baggage cars	3,100	7,000	93

Almost incredible as these advances appear, they are based on the actual purchases of a great Western system during the years in question.

The wages of the men directly employed in the operation of trains show the following increases:

	Average Daily Compensation. 1893.	1905.	Increase per cent.
Engine men	$3.66	$4.16	13.6
Firemen	2.04	2.39	17.2
Conductors	3.08	3.54	15.0
Trainmen	1.91	2.31	21.0

The wages of all other employes concerned in the movement of passenger trains show proportionate advances.

Coincident with this noteworthy advance in the wages of train crews, the number of this class of railway employes has increased from 179,636 in 1893 to approximately 262,000 in 1905, or 45.8 per cent.

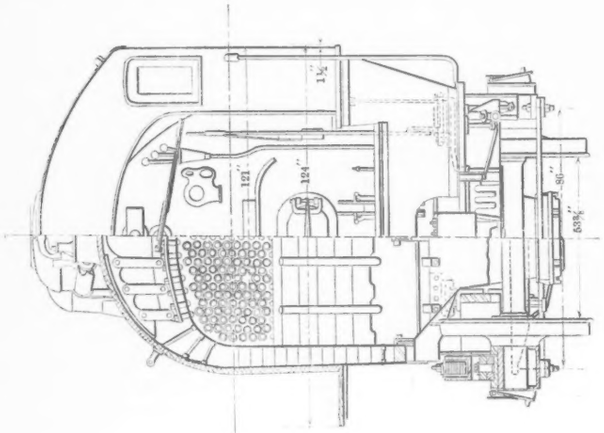
In 1904 fuel for locomotives cost $158,948,886, or 15.8 cents per train mile, against only $74,122,846, or 9.6 cents per train mile, in 1894, the first year the official statistics give figures on the cost of fuel.—*Railway World.*

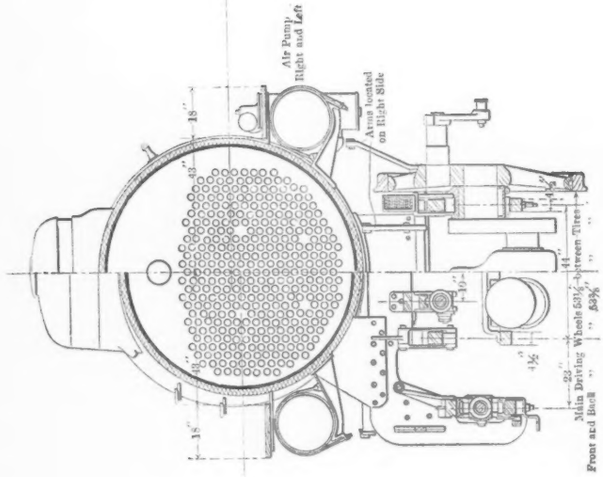
LOCOMOTIVE FOR PENNSYLVANIA STATE COLLEGE.—In response to a request from the school of engineering of the Pennsylvania State College, the Pennsylvania R. R. has sent to the school one of its class D8 locomotives to be used by the students for testing. The board of directors of the railroad have voted to donate this locomotive "when the said college shall have provided a locomotive testing plant," and the college authorities have advised the company that it is expected that the State Legislature at its next session will vote a sufficient sum to completely equip a modern testing plant. When that is done, the engine, which for the present is merely loaned, will become the property of the college.

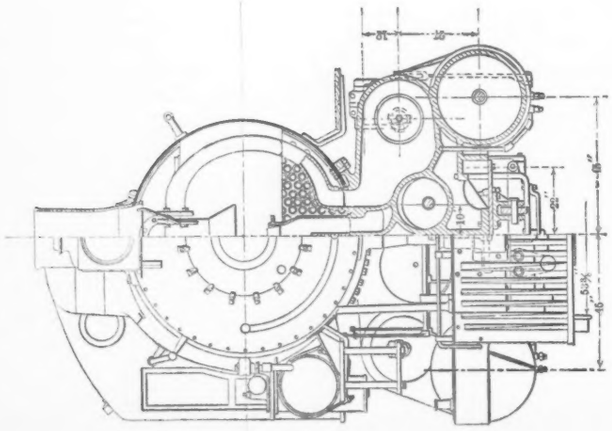
BALANCE COMPOUND PRAIRIE TYPE LOCOMOTIVE WITH INCLINED HIGH PRESSURE CYLINDERS.

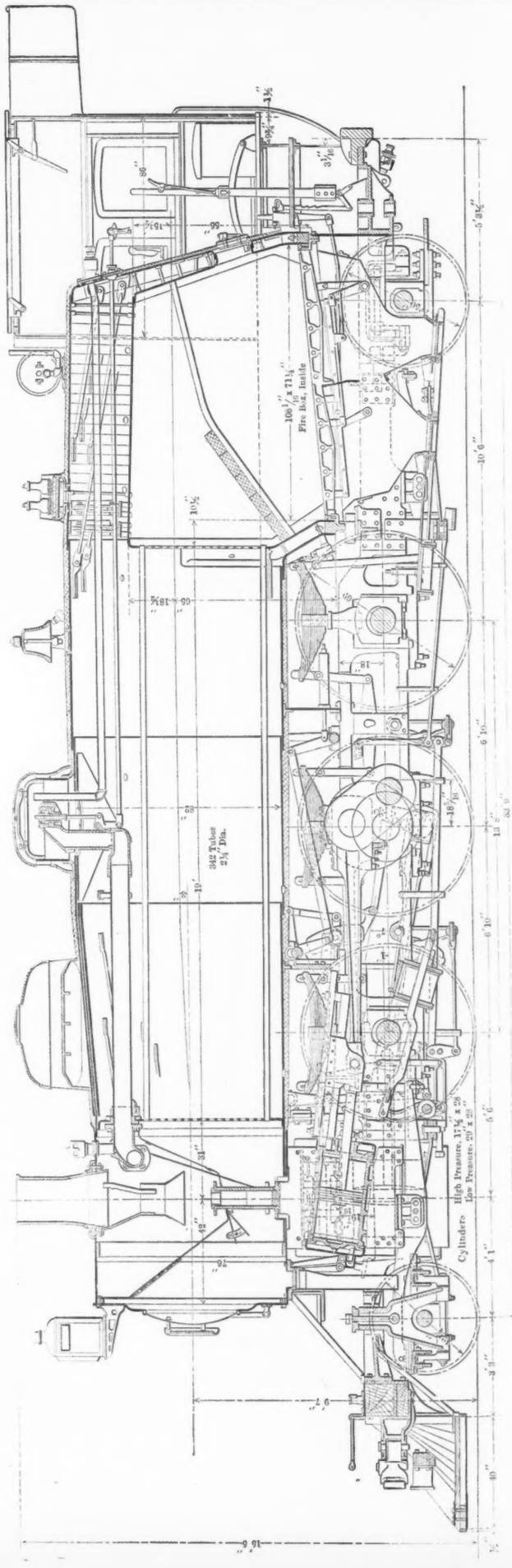
ATCHISON, TOPEKA & SANTA FE RAILWAY.

The Baldwin Locomotive Works are delivering to the Atchison, Topeka & Santa Fe Railway an order of very large and powerful Prairie type locomotives for fast freight service. They are of the Baldwin balanced compound design, and in order to embody this design with this type of locomotive and escape the use of the bifurcated inside main rod for spanning the front axle, the high-pressure cylinders have been raised and inclined sufficiently to allow the inside main rod to pass above the front driving axle. As will be seen by reference to the illustrations this arrangement has not complicated the design









BALDWIN BALANCED COMPOUND PRAIRIE TYPE LOCOMOTIVE, ATCHISON, TOPEKA & SANTA FE RAILWAY.

outside of the cylinders to any appreciable extent. There has been no change made in the cylinder design as far as the balanced principle is concerned, the changes consisting simply in the relocation of the high-pressure cylinders in a higher and inclined position and curving and extending the steam passages to suit. The same type and arrangement of single piston valve, which in this case is operated by the Walschaert gear, that has previously been used on Baldwin balanced compounds, is found here. The inclination of the cylinders has, however, affected the counterbalancing in a peculiar manner, as will be shown in detail.

The Prairie type locomotive for fast freight service, which incidentally includes low-speed heavy passenger service, is becoming quite common in certain sections on Western railroads. During the past few months there have been illustrated in this journal such a design for the Chicago, Burlington & Quincy Railway, where this type has been in very general use for over five years, and in the last issue was shown a similar engine for the Northern Pacific Railway. This one for the Santa Fe, however, is larger and more powerful than either of the previous ones, as can be seen by the accompanying tables of general dimensions, and it also has the further advantage of being a balanced compound.

Owner	A.T.& S.F.	C. B. & Q.	N. P.
Type	2—6—2	2—6—2	2—6—2
Builder	Baldwin.	American	American
Total weight	248,200 lb.	216,000 lb.	209,500 lb.
Weight on drivers	174,700 lb.	159,540 lb.	152,000 lb.
Cylinders	17½ & 29x28 in	22x28 in.	21x28 in.
Diam. of drivers	69 in.	69 in.	63 in.
Steam pressure	225 lbs.	210 lb.	200 lb.
Tractive effort	37,144 lb.	35,060 lb.	33,300 lb.
Total heating surface	4017.8 sq ft	3576 sq. ft.	2340 sq. ft.
Length of tubes	19 ft.	19 ft	13 ft. 3 in.
Weight on Driv. ÷ tractive effort	4.7	4.55	4.55
Trac. Eff. × Diam. Driv. ÷ Heat.Surf.	637.8	677	900
Ttl. Heat. Surf. ÷ Vol. Simp. Cyls.	326	290	209
Reference in AMERICAN ENGINEER	This issue	Aug '06 p 300	Oct '06 p 392

The cylinders are 17½ and 29 x 28 ins., which, with the 225 lbs. steam pressure used and 69-in. drivers, gives a tractive effort of 37,144 lbs. working compound, and can exert a tractive effort of over 50,000 lbs. when operating as a simple in starting. The boiler is large, being 76 ins. at the front tube sheet and increasing in diameter to 82 ins. at the second barrel sheet. It contains 342 tubes 2¼ ins. in diameter, which give a heating surface of over 3,800 square feet. The firebox has a heating surface of 207.3 sq. ft., which makes a total heating surface of the boiler over 4,000 sq. ft., giving about 326 sq. ft. of heating surface per cu. ft. volume of equivalent simple cylinders. The water spaces around the firebox are liberal, and the grate area provides 1 sq. ft. of surface to every 75 sq. ft. of heating surface.

These locomotives weigh 248,200 lbs., of which 174,700 lbs., or over 70 per cent., is on drivers, making them the heaviest Prairie type for either freight or passenger service which we have on our records. The factor of adhesion is 4.7, and the engine weighs 62 lbs. per sq. ft. of total heating surface. The rigid wheel base is 13 ft. 8 ins. The engine was designed for 16-deg. curves.

A very unusual condition is found on these locomotives in that the two main driving-wheel centers are not interchangeable, i.e., there is a different counterbalance weight in each wheel. This, of course, is caused by the 7° inclination of the high-pressure cylinders, which places the cranks of the high and low pressure cylinders on the same side at 187° instead of 180°. The left high-pressure crank is at 83° with the right low-pressure crank, while the right high-pressure crank is at 97° with the left low-pressure crank.

The computation for obtaining the proper weights in each wheel is very interesting.

Through the courtesy of the Baldwin Locomotive Works the following data, compiled by Mr. H. A. F. Campbell, is given in full:

The weights of the rotating parts to be balanced are as follows:

Inside main rod total	650 lbs.
Inside main rod weight to be balanced	424 lbs.
Outside main rod total	725 lbs.
Outside main rod weight to be balanced	418 lbs.
Side rod weight on main pin	572 lbs.
Inside crank pin	137 lbs.
Outside main rod collar and nut	86 lbs.
Outside main side rod pin	93 lbs.
O. S. wrist pin hub	250 lbs.
Eccentric boss + ½ eccentric arm	78 lbs.
Eccentric rod jaw + ½ eccentric rod	45 lbs.
One cheek of crank axle actual	1,425 lbs.
Effect of crank axle cheek at 14 in	712 lbs.
Web concentrated about pin center	873 lbs.
Web remainder	110 lbs.

In order to more easily follow the work, the effect of the different forces has been separately considered. The left I. S. crank is at the forward dead center. All forces and weights act at 14-in. radius and are resolved into their vertical and horizontal components.

Taking movements about C, we have for the right-hand wheel:

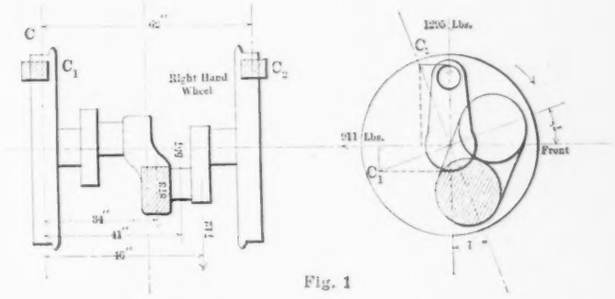


Fig. 1

Downward Forces.	Upward Force.
873 x 34 = 29,680	+ C_1
557 x 41 = 22,837	85,267
712 x 46 = 32,750 C_2 =	$\frac{}{62}$ = 1,396 lbs. acts up
+ 873	— 1,396
+ 557	
+ 712	
+ C_1	
+ 2,142 — 1,396 + C_1	= 0
C_1	= 746 lbs. acts up

1,396 sin. 7° = 170 lbs.
1,396 cos. 7° = 1,386 lbs.
746 sin. 7° = 91 lbs.
746 cos. 7° = 741 lbs.
1,386 — 91 = 1,295 lbs 1
741 + 170 = 911 lbs 2

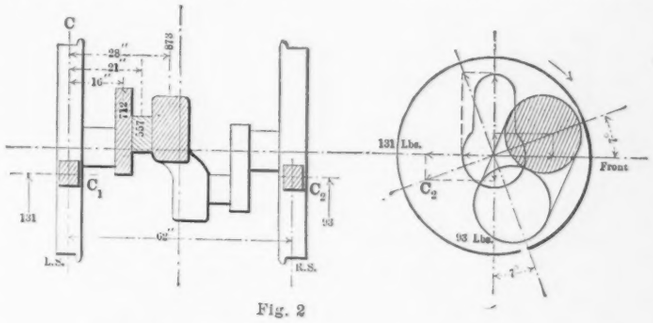


Fig. 2

Downward Forces.	Upward Forces.
C_2 x 62 = 62 C_2	873 x 28 = 24,444
	557 x 21 = 11,697
	712 x 16 = 11,392
	47,533
C_2 =	$\frac{47,533}{62}$ = 766 lbs.
766	873
C_1	557
	712
	2,142
— 2,142 + 766 + C_1 = 0	
C_1 =	1,076 lbs.

766 sin. 7° = 93.3 lbs 3
1,076 sin. 7° = 131 4

The vertical components of these forces are only considered.

Refering to Figure 3.

Effect of 110 lbs. at 14" = $\frac{110 \times 19\frac{1}{4}}{14}$ = 151 lbs.

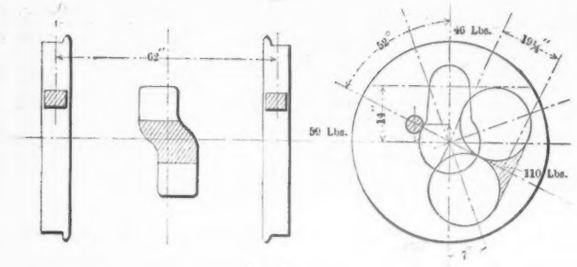


Fig. 3

Has to be balanced by two weights, one in each wheel.

$$\frac{151}{2} = 75 \text{ lbs.}$$

75 x sin. 52° = 59 lbs 5
75 x cos. 52° = 46 lbs 6

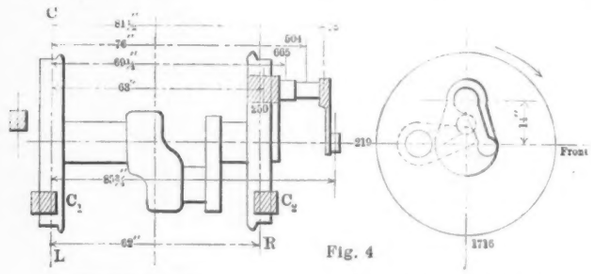


Fig. 4

Downward Force.	Upward Force.
$C_2 \times 62 = 62C_2$	250 x 63 = 15,750 665 x 69¼ = 46,051 504 x 76 = 38,304 78 x 81½ = 6,357 106,462
$C_2 =$	$\frac{106,462}{62}$ = 1,716 lbs. acts down .7
+ 1,716	— 250 — 665 — 504 — 78 — C_1
$C_1 + 1,716$	— 1,497 = 0
C_1	= 219 lbs. acts up.....8

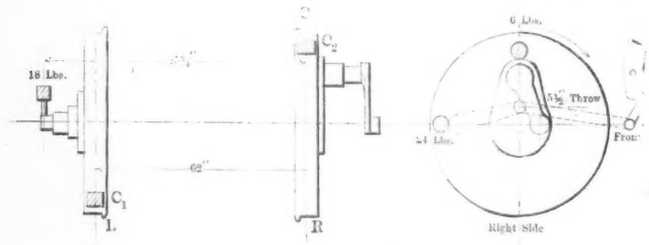


Fig. 5

Effect of weight of eccentric rod boss and ½ eccentric rod at

$$14" = \frac{45 \times 5\frac{1}{2}}{14} = 18 \text{ lbs. nearly}$$

$$C = \frac{85\frac{3}{4} \times 18}{62} = 23.51 \text{ lbs.} = 24 \text{ lbs} \quad .....9$$

$$+ 23.5 - 18 + C_2 = 0$$

$$C_2 = 5\frac{1}{2} \text{ lbs.} = 6 \text{ lbs} \quad .....10$$

Combining all horizontal and vertical forces 1—2—3—4—5—6—7—8—9—10 separtely, we have—

Horizontal — 911 + 131 + 59 + 219 + 24 = 1,346 lbs.

Vertical 1,295 — 93 + 46 — 1,716 + 6 = 462 lbs.

Hence the counterbalance weight will be placed at an angle whose tan. = 462 ÷ 1,346, which is 18° 57′ (or 19°) + 90° = 109° back of the right-hand wrist pin. Its magnitude will be the resultant of these two forces.

The resultant = R = $\sqrt{1,346^2 + 462^2}$ = 1,423 lbs. (at 14″ radius). The counterbalance weight will act at a radius of about 22 in., and hence equals—

$$\frac{1,423 \times 14}{22} = 905 + \text{lbs.}$$

in the right-hand wheel.

Similarily for the left-hand wheel with the right-hand inside crank at the back dead center

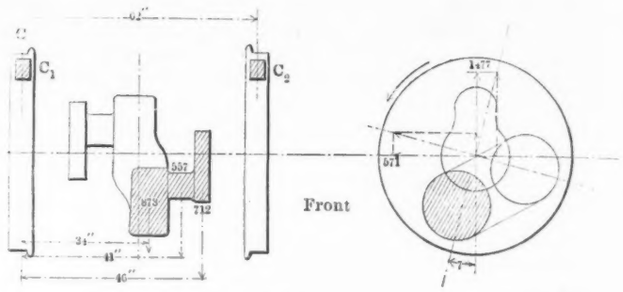


Fig. 6

Downward Forces.	Upward Forces.
873 x 34 = 29,680 557 x 41 = 22,837 712 x 46 = 32,750 85,267	$C_2 \times 62 = 62C_2$
$C_2 =$	$\frac{85,267}{62}$ = 1,396 lbs. acts up
+ 873 + 557 + 712 + C_1	— 1,396
+ 2,142 — 1,396 + C_1	= 0
C_1	= 746 lbs. acts up.

1,396 sin. 7° = 170 lbs.
1,396 cos. 7° = 1,386 lbs.
746 sin. 7° = 91 lbs.
746 cos. 7° = 741 lbs.
1,386 + 91 = 1,477 11
741 — 170 = 571 12

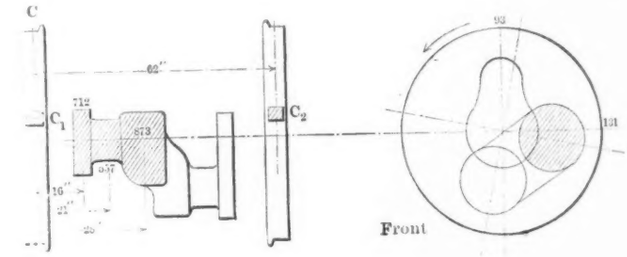


Fig. 7

Downward Forces.	Upward Forces.
$C_2 \times 62 = 62\ C_2$	873 x 28 = 24,444 557 x 21 = 11,697 712 x 16 = 11,392 47,533
C_2	$\frac{47,533}{62}$ = 766 lbs.
+ 766 C_1	— 873 — 557 — 712
— 2,142 + 766 + C_1	= 0
C_1	= 1,076 lbs.

766 sin. 7° = 933 lbs 13
1,076 sin. 7° = 131 lbs 14

The vertical components of these forces are only considered.

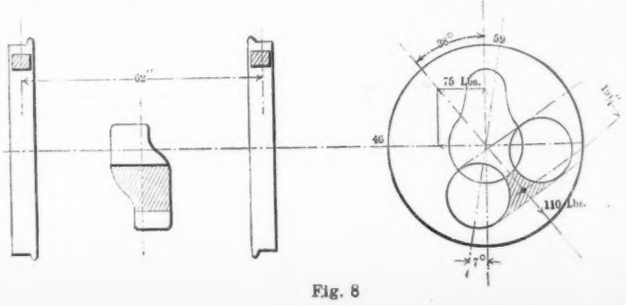


Fig. 8

Referring to Figure 8

$$\frac{110 \times 19\frac{1}{4}}{14} = 151 \text{ lbs. at 14 inches radius.}$$

This has to be balanced by two weights, one in each wheel.

$$\frac{151}{2} = 75 \text{ lbs.}$$

75 x sin. 38° = 59 lbs. 15
75 x cos. 38° = 46 lbs. 15

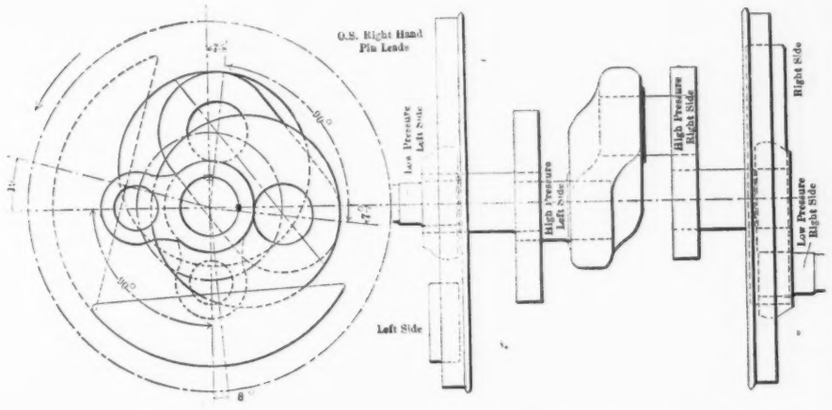
The weights of the outside rods, pins and eccentric boss and rod are the same as for the right-hand wheel (see Figs. 4 and 5), except that the eccentric boss and rod act in the opposite directions.

Thus combining as before we find the horizontal forces to be $571 - 131 + 46 + 219 - 24 = 681$ lbs., and the vertical forces equal $1{,}716 + 6 - 1{,}477 - 93 - 59 = 93$ lbs.

Hence the counterbalance weights will be placed at an angle whose tan. = 93 ÷ 681, which is practically 8 deg. This weight will have to be such as to balance the resultant of these two forces acting at a 14-in. radius. This resultant $R = \sqrt{681^2 + 93^2} = 687$ lbs.

The counterbalance weight will act at a radius of about 22 ins., and hence equals about 440 lbs. placed in the left-hand wheel.

These weights counterbalance the rotating parts only, as is evident from a study of the above data, and by a careful arrangement in the design, the reciprocating weights are so nearly alike between the high and low-pressure cylinders on the same side of the engine as to almost exactly balance themselves, and hence are disregarded altogether. The high-pressure piston is made solid and heavy, and the low-pressure piston is made as light as possible. While, of course, there is a slight difference in other parts of the high and low-pressure side, it is not sufficient to exceed the amount which is allowed by the master mechanic's rule to remain unbalanced.



The photograph, giving a general view and more details of this locomotive in connection with the cylinders and valve gear, will be given in the next issue. The general dimensions, weights and ratios are as follows:

FOUR-CYLINDER BALANCED COMPOUND FREIGHT LOCOMOTIVE.

ATCHISON, TOPEKA & SANTA FE RAILWAY.

GENERAL DATA.

Gauge	4 ft. 8½ in.
Service	Fast Freight
Fuel	Bit. coal
Tractive effort comp.	37,144 lbs.
Weight in working order	248,200 lbs.
Weight on drivers	174,700 lbs.
Weight on leading truck	31,800 lbs.
Weight on trailing truck	42,200 lbs.
Weight of engine and tender in working order	418,000 lbs.
Wheel base, driving	13 ft. 8 in.
Wheel base, total	33 ft. 9 in.
Wheel base, engine and tender	64 ft. 7½ in.

RATIOS.

Weight on drivers ÷ tractive effort	4.7
Total weight ÷ tractive effort	6.7
Tractive effort × diam. drivers ÷ heating surface	637.8
Total heating surface ÷ grate area	75
Firebox heating surface ÷ total heating surface %	5.2
Weight on drivers ÷ total heating surface	43.5
Total weight ÷ total heating surface	62
Volume equiv. simple cylinders	12.3 cu. ft.
Total heating surface ÷ vol. cylinders	326
Grate area ÷ vol. cylinders	4.35

CYLINDERS.

Kind	Bal. Comp.
Diameter and stroke	17½ & 29 x 28 in.
Kind of valve	Piston

WHEELS.

Driving, diameter over tires	69 in.
Driving, thickness of tires	3½ in.
Driving journals, main, diameter and length	11 x 10½ in.
Driving journals, others, diameter and length	10 x 12 in.
Engine truck wheels, diameter	42¼ in.
Engine truck, journals	6½ x 12 in.
Trailing truck wheels, diameter	50 in.
Trailing truck, journals	8 x 14 in.

BOILER.

Style	E. W. T.
Working pressure	225 lbs.
Outside diameter of first ring	76 in.
Firebox, length and width	108 1/16 x 71 1/4 in.
Firebox plates, thickness	3/8 & 9/16 in.
Firebox, water space	F4½-S & B4 in.
Tubes, number and outside diameter	342 2¼ in.
Tubes, length	19 ft.
Heating surface, tubes	3,810.5 sq. ft.
Heating surface, firebox	207.3 sq. ft.
Heating surface, total	4,017.8 sq. ft.
Grate area	53.5 sq. ft.
Smokestack, height above rail	15 ft. 5 in.
Center of boiler above rail	9 ft. 7 in.

TENDER.

Wheels, diameter	34¼ in.
Journals, diameter and length	5½ x 10 in.
Water capacity	9,000 gals.
Coal capacity	12 tons

COLLEGE MEN IN RAILROAD SERVICE.—College men are taken with a grain of salt, not because they are inferior, for, on the contrary, they may be good men of sound minds, but they are pretty much like that useful article known as a frying pan without a handle, wherein it is possible to melt good fat and prepare a solid meal, but without the handle it is difficult to make prompt and practical use of it, and burnt fingers are the result. I believe that the average college man will not at first find the railroad service a very attractive field, nor will the railroad official consider him a very attractive "find," until both understand each other better. The railroad man should realize that the college man has, or ought to have, a better developed mind and body and be trained to co-operate with others in obtaining results, and, secondly, the college man must appreciate the necessity of getting down to business.—*A. J. County, Asst. to Third Vice-Prest. P. R. R. Co., in "Railroad Men."*

NAMING LOCOMOTIVES.—The following note, taken from a recent issue of *The Locomotive Magazine*, may recall to the minds of some of our readers the time when locomotives were not quite as numerous in this country as at present. It is surprising to learn, however, that the road in question has over 850 locomotives: "The following is the list of names allotted to the new Atlantic type locomotives for the North British Railway, illustrated and described in our last issue: 'Aberdonian,' 'Abbottsford,' 'Bon Accord,' 'Borderer,' 'Cumberland,' 'Dunedin,' 'Dundonian,' 'Hazeldean,' 'Midlothian,' 'St. Mungo.' 'Teviotdale,' 'Thane of Fife,' 'Tweeddale' and 'Waverley.'"

CONGESTION IN THE PATENT OFFICE.—Mr. Fred W. Barnaclo, in a recent issue of the New York *Commercial*, calls attention to the serious situation confronting the patent office at Washington. On the first of this year the patent office had 17,353 applications waiting for action. The *Official Gazette* for September 25 shows that this number has now increased to 23,468. The number of applications received weekly varies from 800 to 1,200, and the average weekly excess over the number issued during the past nine months has been 170. The force of examiners allowed the patent office is not large enough to handle the great number of applications now coming in and the office is getting further and further behind in its work. At the present time some departments are back from six months to a year—that is to say, this time must elapse after application is made before the applicant receives notice that his case is under consideration.

COMMUNICATIONS

M. M. AND M. C. B. ASSOCIATION.

To the Editor:

I am glad to read what is said editorially in the September number suggesting improvements in the methods of conducting the Master Mechanics' Association meetings and think that the points are well taken. I believe that there is some feeling that we are not giving the proper attention to the subjects which are presented. An additional criticism that I would make is that the program is not carried out according to schedule, so that persons desiring to be present during the discussion of a particular topic may find on arrival that that topic has been passed two hours in advance without discussion and dropped. Such occurred during the last session of the late convention.

BOSTON, Mass. C. B. SMITH.

THE SURCHARGE PROBLEM.

To the Editor:

At the bottom of page 376 in the October issue, in the article entitled "The Surcharge Problem," by Mr. C. J. Morrison, is given a detailed example of the computation of cost of manufacture of a given article. Then follows the statement: "We now know *beyond the shadow of a doubt* whether to buy or manufacture this article, *as the decision hinges on whether the price is below or above* $2.60." The solution of the problem does not seem to me to be quite so simple.

Let it be supposed that the market price of the given article is $2.50. According to the figures given, it would be more economical to discontinue its manufacture and purchase on the market. If this was done, what would become of the 40 per cent. surcharge? I do not believe that in this particular case it would be reduced more than 10 per cent. The remaining 45 cents would simply be loaded on to the other work carried on in the shops, unless the shop superintendent was able to manufacture in place of the article in question some other article whose shop cost, computed in this way, would, when compared with the market price, make a more favorable showing.

I do not believe, when once a railroad shop is built and equipped and its organization established, that its surcharges either "money" or "book" are likely to be affected very much by the manufacture or discontinuance of manufacture of any single article.

In the particular example given Class I. would not likely be affected at all, Class II. in Division D only, and Classes III. and IV. reduced very little, and, unless some other article was substituted for manufacture to keep the shop working to the limit of its capacity, probably 90 per cent. of this 40 per cent. surcharge would have to be paid just the same in addition to the market price.

Yours truly,

THEO. F. H. ZEALAND.

Illinois Central, Chicago.

To the Editor:

The article on the surcharge problem in your last number is a beacon ray of light on a very foggy situation. The analysis given seems to me to be very clear and simple to follow, and worthy of careful attention.

The customary treatment of this subject is contented with a hit or miss, flat blanket rate, evolved from the accounting department. Machines known to be uneconomical are shipped around from one shop or division to another, unable to find the scrap pile as long as they will possibly turn. It is very hard to get cash appropriations for their replacement, without the aid of such a surcharge study. I have in mind a certain driving-wheel lathe of the vintage of 1860, which was condemned as useless, and shipped away from a four-pit shop in the eighties. Apparently it went on the extra list because, some fifteen years later, after suffering the annoyance of sending all wheels 170 miles for tire turning, a new lathe was requisitioned, the old veteran reappeared, and the shop was compelled to reinstall it or do without.

A more widespread knowledge of cost would seem to be advisable. It is general practice to-day to show the cost of rough parts upon the tag at the storehouse bin, but neither the workman nor his foreman have an idea of the actual cost of the article by the time it is applied to the locomotive.

It is even worse in the draughting room. The railroad designer ordinarily contents himself by getting out something that will do the work and not weigh too much. The successful industrial designer, however, must be an expert mechanic as well, and acquainted with the detail costs of manufacture in order to produce the cheapest possible design.

The text of the entire article is found in the last paragraph, a text which has been preached so often to railroad officials. That it is possible to save money by spending money appears to be a more difficult mental process for the average railroad man than for his industrial neighbor. Very truly yours,

New York. PAUL R. BROOKS.

To the Editor:

Mr. Morrison's article in your October issue strikes what I believe to be the weakest point in the mechanical departments of our railroads to-day. All of them are manufactors to a greater or less extent, and in most cases, are undoubtedly carrying on this work without applying the most simple principles of industrial accounting, and without any real knowledge of whether that part of the shop output is a paying proposition in its details or not.

The surcharge as Mr. Morrison clearly shows, is a very large factor in the cost of any manufactured article, and a flat rate or percentage added to the labor and material charge, in any particular case, will not give a true value. This will actually be found to vary by wide limits on both sides of the figure obtained in that way.

It seems to me that a careful investigation of this subject in the railroad shops will be of benefit in more ways than in giving exact costs of manufactured articles. It will undoubtedly, if the charges carried by each machine in the shop are put in a clear tabular form, tend to influence a foreman to keep his shop evenly balanced, and keep all his machines in operation at their maximum capacity. It will give a correct index of each foreman's managing ability, as compared with other foremen. It will settle the question of purchasing new and better machinery without any doubt. It will tell whether it will pay to tear out the present steam power plant which transmits power through long lines of shafting, cables and steam pipes, and install an electric drive. In fact, the uses to which detailed figures on the subject as outlined in your article can be put, are almost without number, and I hope to see you give us more on the subject.

I would suggest that an article showing the methods used in arriving at the proper charge for different machines, possibly put in algebraic form, would no doubt, be much appreciated by many of your readers, as well as by myself.

Yours truly,

F. B. B.

To the Editor:

Referring to the article on "The Surcharge Problem" by Mr. C. J. Morrison on page 376 of your October issue, and also to your editorial on page 391. The ideas are very good but I am afraid that their practical application would present many difficulties on the average railroad. For instance, the method of keeping accounts on the road with which I am connected is such that it is very questionable whether we would be able to obtain accurate information concerning the various items which go to make up these surcharges. The arguments presented, however, are certainly good and I for one would like to have you publish more detailed information concerning the method of applying and using such a system if, as apparently suggested, it is in actual use in a railroad repair shop.

It is true that many manufacturers are accustomed to study very closely this matter of surcharges, but their work is entirely different from that which is done in a railroad repair shop. Machines or other work are put through the shop in quantities and there is practically no repair work to handle. The manufacturing concerns which use such a system, and with which I am acquainted, are very much smaller and the organization is not nearly as complicated as that of a railroad shop. Under these conditions it is comparatively easy to calculate the surcharge on the various machines, but the varied amount of work which may be handled on a single machine in a railroad repair shop is such that it would seem that only a very rough estimate can be made as to the amount of the surcharges on any one man or machine for a particular piece of work. On machines where work of only one kind is done the difficulties would not be as great. Could not Mr. Morrison present some figures as to the increase in the force which would be required to instal a system of this kind in a shop which has to take care of 300 locomotives?

SHOP SUPERINTENDENT.

THE DRAFT GEAR SITUATION.

To the Editor:

During the past year or two the railroad club proceedings, technical journals and railway mechanical association proceedings have contained a number of articles concerning the advantages of friction draft gears as compared to spring gears. However, although the friction gears have in many instances been in service for a number of years, their advantages are usually stated in general terms, and have not been reduced to a dollar-and-cent basis. In spite of the many good things which have been said concerning this type of gear, it would appear from a study of the equipment notes in the various journals that the percentage of cars which are being equipped with friction gears is very small compared to the number which are being built. If the friction gear has so many advantages, why is it that it is not more generally used, especially as in many instances we find that the spring rigging costs practically as much as the friction rigging.

The very elaborate tests which were reported by the committee on draft gears at the 1902 convention of the Master Car Builders' Association showed conclusively that, as far as the drop tests and the static tests were concerned, the friction rigging was far superior to the spring rigging. Unfortunately, neither one of these two tests fulfill the conditions which are met in service, and therefore they have not carried the weight that they would if they had been made under conditions more nearly approximating those met in service. With the great increase in the capacity and size of locomotives, cars and trains the matter of using the best draft gear becomes an exceedingly important one, and it would seem that this question should be decided as soon as possible, since the friction gears have apparently passed the experimental stage. It is understood that several roads have made tests of the different types of draft gears, but, if so, very little, if any, of this information has been given out. Would it not be possible for the Master Car Builders' Association to build a testing machine or else conduct service tests which would show the exact action of the different gears under service conditions? The problem of building a testing machine to meet those conditions ought not to be a very serious one, or if this course is not feasible it ought to be possible to have extensive service tests made on some of the roads under the jurisdiction of a Master Car Builders' committee. Doubtless the manufacturers of both the spring and friction gears would look with favor upon such tests, if carefully made, in order to show conclusively the advantages of the two types of gear, and the results would probably be such as to make possible a considerable financial saving to the railroads.

MINNEAPOLIS, Minn. A. RAIL ROADER.

HOW CAN THE CO-OPERATION OF THE ORDINARY MECHANIC BE OBTAINED IN INCREASING SHOP OUT-PUT?

To the Editor:

This is a question of great importance to the mechanical department, and it is more in the line of receiving suggestions or criticisms from others than from the value of any ideas presented in this article that it is written.

I think that no one will dispute that 99 per cent. of the actual work, either in repairing old or building new engines, is done by the ordinary mechanic who has learned his trade through actual experience in the shop, combined in many instances with self-education along technical lines by the reading of books, technical journals, etc. This being the case, there is a question whether the upholding of the technical graduate in the form of special apprenticeship, with the understanding that as soon as possible he is to secure whatever plums there are on the tree, has not had a deterrent effect on the best of the rank and file, and has caused them to take less interest in their work and discouraged them in bringing forward ideas that would better prevailing methods, thus increasing the output.

It is said that you cannot keep the man down who is bound to rise, and while this may be true, still it will usually be found that those who have attained great success through their own efforts have received encouragement in their ascent, and the prospect of further promotion has been held out to them from time to time.

Other reasons why ordinary workmen refrain from advancing suggestions for the improvement or increase of production are the way they are received, they being sometimes told by persons in authority that others are paid for doing that kind of work, or, in other words, that they had better stick to their hammer and chisel and other people would furnish the brains. That this is at all universal is by no means claimed, but it is not entirely unknown. Again, how often it is that a workman advances an idea that is adopted and proves successful, and it is then spoken of and shown by his superiors as something we have gotten up, with a special emphasis on the *WE*. In addition the ambitious, practical man who does things has also to meet the opposition and sometimes the derision of his fellows, especially of those who have little ability and less ambition.

Another point worth looking into is the bad effect produced by the equal wage rate that is in force in nearly all shops having agreements with labor organizations. In almost every case the minimum rate is also the maximum, and this results in putting the poorest man in the shop on an equal basis with the best one as regards wages paid. The result is plainly to be seen when you have the best and poorest man in the shop on opposite sides of an engine doing the same class of work. It is open to question, if it would not be economy for the railroads of their own volition to adopt a higher rate for the exceptionally good men, as it would be something to strive for, rather than to have all ambition destroyed by one universal flat rate.

Some one will suggest piecework as a remedy, but can it be denied that the antagonism to it by all labor organizations is due to injustice from it in the past, and is there any guarantee that the world has grown so good that the same conditions will not exist in the future?

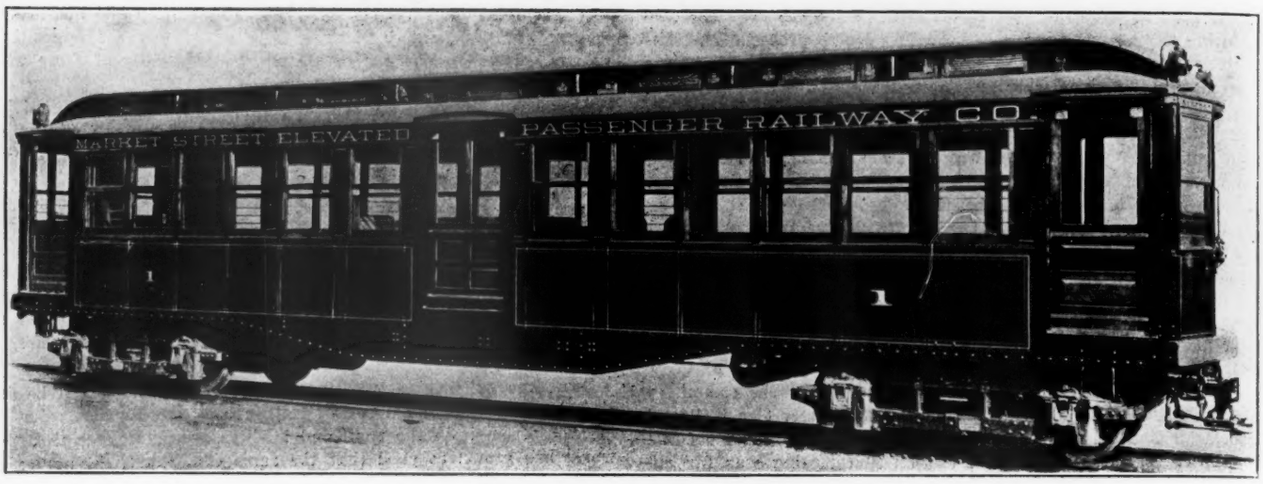
What, then, are the remedies? The following are suggested: The capabilities of men to be closely followed, and the men with the necessary qualifications to be promoted as vacancies occur. That the advancement of ideas and the giving out by the men of the best that is in them be more encouraged, and, if an idea is adopted and is a pronounced success that some return, either in the shape of money or some other consideration, be made to the inventor. Teaching the individual and organizations that cheapening production does not cheapen labor, but enlarges the field of use and benefits the world at large. The treatment of all employees with courtesy and friendliness. Absolute truthfulness in all dealings and the rigid keeping of all promises and agreements. The encouragement of study, especially of technical books and magazines, by all and most strongly by apprentices; to this the study of mechanical drawing should be added where possible. Fostering the spirit through the shop that we desire to be in the van and not in the rear, no matter how small the shop. Cleanliness in the shop is necessary, and moral tone should be encouraged, as the man is to a great extent influenced by his surroundings. A man cannot be expected to take an interest in his work if he is falling over scrap in the machine shop, or working on the top of an ash heap, or in a pool of water in the roundhouse. Carefully note the result of substituting the men who are considered best able to fill the position in place of absent foremen, without tying their hands. These ideas are advanced as having a tendency in the right direction.

In conclusion, would say that the remuneration for ideas is considered to apply to the ordinary workingman only, as it is considered that it is the foreman's duty to be thinking along this line and of doing everything in his power to promote his employer's interest; if he is not doing so he is unworthy of the position he occupies. What has been said regarding technical graduates is with no prejudice against them, as many of them have worked under my supervision and are among my best friends, but while no one can question that the thoroughly practical man with a thorough technical education is the best man to be procured, it is doubtful if the ordinary technical graduate is of any more value in railroad work, outside of testing operations, than the better class of ordinary apprentice, and if he wishes to attain prominence in the mechanical department he should willingly meet the ordinary apprentice on an equal footing, and his superior education will give him so much of an advantage that, other talents being equal, he should have no fear of results.

WINONA, Minn. CHARLES COLEMAN,
General Foreman, C. & N. W. Ry.

THE FIRST ELECTRICAL TRAIN to enter the Grand Central Station, New York, ran from High Bridge, a distance of about 7½ miles, into the station and return on September 30. Mr. W. J. Wilgus, vice-president of the New York Central, acted as motorman, and in the train were a number of officials of the road and their guests.

THE STRENGTH OF A GRINDSTONE appears, from recent tests, to vary widely with the degree of its wetness or dryness: stones that are dry showing tensile strengths of from 146 to 186 lbs. per sq. in, but, after soaking over night, breaking under stresses of 80 to 116 lbs. per sq. in.—*Engineering Record.*



GENERAL VIEW OF STEEL PASSENGER CAR.

STEEL PASSENGER CAR WITH SIDE DOORS.

The Pressed Steel Car Company has recently built 40 steel passenger cars with side doors for the Market Street elevated and subway line of the Philadelphia Rapid Transit Company. The framing throughout, as well as the side sheathing, is of steel construction. The underframing consists of deep fish-belly side sills, with cross bearers and connections in girder form. The general dimensions are as follows:

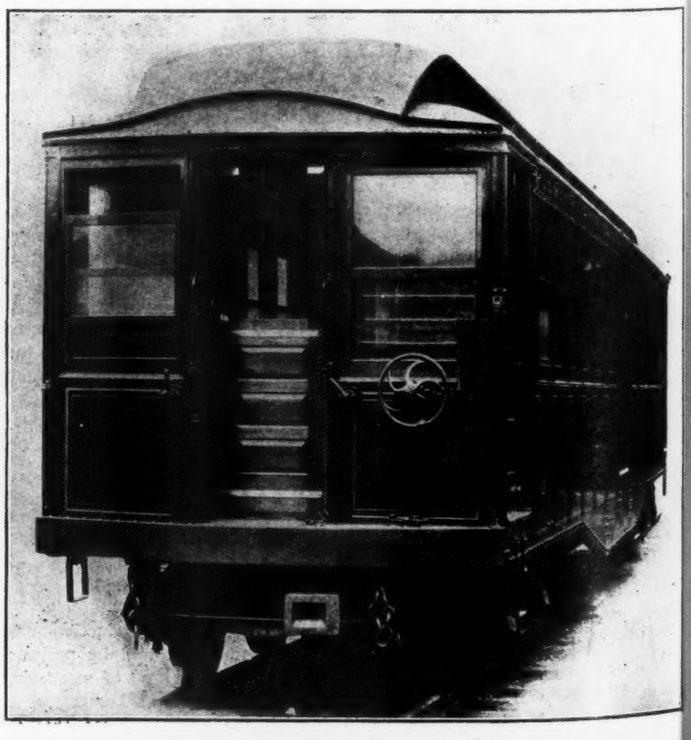
Length over platform (over all)	49 ft. 7¼ ins.
Length over door posts	40 ft. 6¼ ins.
Length inside of car (end lining)	39 ft. 6¼ ins.
Width of car outside of side sheets	8 ft. 7 ins.
Width of car inside	7 ft. 7¾ ins.
Height from rail to top of floor	3 ft. 10 ins.
Height from floor to ceiling (center)	8 ft. 6½ ins.
Height from rail to top of car	12 ft. 7 ins.
Opening for vestibule side door (between door posts)	2 ft. 9 ins.
Width of end door opening	3 ft. 2½ ins.
Width of center door opening (side)	3 ft. 4 ins.
Distance from center to center of trucks	34 ft. 6 ins.
Width over eaves-upper deck	5 ft. 6¾ ins.
Width over eaves-lower deck	8 ft. 8⅝ ins.
Width of vestibule end door opening	2 ft.

The 12 carlins are of 1½ x 1½-in. steel. The underframe is covered with corrugated steel sheets and monolithic flooring composition. The roof is constructed of tongue and groove poplar, ½ in. thick, covered with eight-ounce cotton duck. The side doors, both at the ends and at the center, are arranged for opening and closing from either end of the car by means of pneumatic devices. The doors are of mahogany, with the lower half paneled, and one light of ¼-in. plate glass in the upper half. The interior finish is of straight-grained mahogany. There is a motorman's cab at each end of the car. The seating arrangement consists of four longitudinal seats for nine persons each and eight cross seats in the center of the car for two persons each. Of the 24 side windows 18 have the upper sash movable and the lower sash stationary. The cars are equipped for heating and lighting by electricity.

These are among the first cars built by the new passenger car works of the Pressed Steel Car Company. The first car was completed in the early spring for the United Railways of San Francisco, and was an all-steel car of the "California" type. Following this three combination steel and wood passenger cars were built for the Southern Railway. These were illustrated and described on page 260 of our July issue. Following these were the 40 cars as described above for the Philadelphia Rapid Transit Company.

SPEED OF EMERY WHEELS.—Ordinarily, emery wheels give best results when run at a peripheral speed of 5,500 ft. per minute. If run too fast, they will heat the work and glaze, and, if run too slowly, will wear away rapidly and do but little work.

MALLEABLE IRON, PHYSICAL PROPERTIES.—Designers in general, in making use of malleable iron castings, proceed without definite knowledge as to the physical properties of this material, so far, at least, as its tensile strength and elongation are concerned. Mr. G. A. Ackerlind read before the Scandinavian Technical Society recently a paper in which he gave some definite information as to the properties of malleable cast iron, as made in that country. This information is doubtless applicable to American irons as well. He states that the tensile strength for this material varies between 40,000 lbs. and 50,000 lbs. per sq. in. It has elongation varying from 1 to 6 per cent., with a reduction of area of ¾ to 3 per cent. The ordinary grade of cast iron, having a tensile strength from 20,000 to 30,000 lbs. per sq. in., is therefore only about half as strong as malleable cast iron; its compressive strength, however, is much greater. Malleable cast iron shrinks more in the mold than cast iron, but during the process of annealing a slight swelling takes place. If malleable castings have to be straightened by hammering, nothing is gained by heating them, the normal temperature of the surrounding air being satisfactory for this purpose.—*Machinery.*



END VIEW OF STEEL PASSENGER CAR.

THE ECONOMICAL WORKING OF LOCOMOTIVES.

Mr. William Ernest Dalby, in a paper (No. 3,577) presented before the Institution of Civil Engineers, investigates the economical working and design of simple locomotives with reference to certain considerations which, although known in a general way, have not, in his opinion, received the attention they deserve.

The results of his investigation and analysis are summed up very nicely in the following conclusions:

1. The mean pressure in a locomotive cylinder, with boiler pressure and cut-off constant, and the regulator wide open, decreases as the speed increases.

2. The law connecting the mean pressure with the piston speed is approximately linear and of the form

$$p = c - bv,$$

where c and b are constants found by experiment, and p is the mean pressure in pounds per square inch corresponding to a piston speed of v feet per minute.

3. In consequence of this dropping of the mean pressure with the speed, there is one piston speed at which the indicator horse power is a maximum, and this speed is given by

$$v = \frac{c}{2b},$$

the corresponding value of the mean pressure being

$$p = \frac{c}{2},$$

and the corresponding value of the maximum horse power

$$\text{I.HP.}_{max} = \frac{c^2 a}{132{,}000\, b}.$$

4. In the absence of a series of experiments connecting p and v, c may be taken to represent the mean pressure for the stated cut-off and initial pressure, neglecting all wire-drawing effects, and b may then be found from the equation

$$b = \frac{c - p}{v},$$

p and v being the corresponding values of the mean pressure and piston speed found from an indicator-diagram taken at a piston speed of about 800 ft. per minute.

5. In this way a series of values of c and b may be easily found, and may be used to determine approximately the best piston speed for each particular cut-off.

6. The best piston speed for the maximum drawbar horse power is less than that for the maximum indicator horse power, and can be readily found when the efficiency of the engine itself is known.

7. The drop in pressure could possibly be reduced materially by designing short, straight ports of ample area and avoiding all crooked passageways for the steam.

Application of Results to Solution of Problems.—The foregoing results may be readily applied in the solution of many useful problems. For example, let it be required to find the speed on the level corresponding to the maximum drawbar horse power for a stated cut-off and boiler pressure.

The diameter of the driving wheel must be given, in order to express the train speed in terms of the mean piston speed, and also some estimate must be made of the engine resistance. The latter, reckoned up to the drawbar, may be expressed as a function of the load, or of the speed, or of both the load and the speed, but for the purpose in view it may be taken as constant and equal to 30 lbs. per ton at all speeds.

Let R denote the constant engine resistance in lbs. per ton,

W the weight of the engine and tender,
s the stroke in inches,
D the diameter of the driving wheel in inches,
v the piston speed in feet per minute,
V the train speed in feet per minute,
a the joint area of the two cylinders in sq. ins.

Then the rate at which work is done against engine resistance is

WRV foot-lbs. per minute.

But $$V = \frac{v\pi D}{2s},$$

therefore the rate of working against the engine resistance is

$$\frac{WRD\pi v}{2s} = Qv,$$

where $$Q = \frac{WR\pi D}{2s}$$

and the rate of working in the cylinders is

pva, where $p = c - bv$.

Therefore the rate of working at the drawbar is given by

$$U = (c - bv)\, av - vQ \text{ foot-pounds per minute}$$

And this is a maximum when

$$\frac{dU}{dv} = 0.$$

That is, when $$v = \frac{ac - Q}{2ab}$$

The problem may be extended to find the speed at which the drawbar horse power is a maximum, it being given, in addition to the data of the previous problem, that the train is to ascend a gradient of 1 in G.

The additional engine resistance against the gradient is $R_1 = \frac{2{,}240}{G}$ lbs. per ton, so that the total engine resistance against the gradient is $\frac{W\ 2{,}240}{G}$. The rate of working against this resistance is $\frac{2{,}240\ WV}{G}$ foot lbs. per minute;

and expressing V in terms of the mean piston speed this becomes

$$\frac{2{,}240\ Wv\pi D}{2sG} = vQ_1$$

where $$Q_1 = \frac{2{,}240\ W\pi D}{2Gs}.$$

The rate of working at the drawbar is now

$$pva - (Q + Q_1)\, v,$$

and from this, the speed for a maximum, found as in the previous example, is

$$v = \frac{ac - (Q + Q_1)}{2ab}$$

The more practical problem of calculating approximately the maximum load which an engine will take up a given gradient at a stated speed, cut-off and boiler pressure can be solved without difficulty if the engine and train resistances are known.

GRINDING HIGH-SPEED STEEL TOOLS.—High-speed steel tools can be ruined very easily in the machine shop by grinding them on the emery wheel until they get hot and then plunging them into water. After doing this, the cutting edge of the tools will be found full of cracks. One machine foreman complained that the tool dresser was cracking the tools in hardening, but a careful investigation showed that the tools had been cracked by grinding in this way. The man was instructed how to grind the high-speed tools properly and that put an end to the trouble from cracks in the tools.—*J. G. Jordan in I. R. M. B. Convention.*

STANDARD SYMBOLS FOR WIRING PLANS have been adopted by the National Electrical Contractors' Association, whose secretary, Mr. W. H. Morton, 94 Genesee Street, Utica, N. Y., has ready, for free distribution, sheets giving full information concerning them.

SHOP TESTS TO BE MADE OF AIR PUMPS AFTER GENERAL REPAIRS IN THE SHOPS

Test No	Name of M'n'f'r. of Pump	Size of Pump	Main Res'r Capacity Cu. In.	Steam Pressure in Lbs.	Position of Steam Throttle	Main Reservoir Pressure in Lbs.	Duration of Test Minutes	Size of Opening in Diaphragm through which Air is wasted	Thickness of Diaphragm not more than	Results Desired
1-A	Westing-house	11 In.	22,200	160	Full Open	At beginning Atmospheric at close 150	3	No Waste		At end of 3 Minutes Reservoir Pressure to be not less than 150 Lbs.
2-A	Westing-house	11 In.	22,200	160	Partly Open to give Speed of 52 Cycles per Min.	Maintained Constant at 75 Lbs.	60	13/64 In.	1/8 In.	Maintain Reservoir Pressure at 75 Lbs. for 60 minutes, at 52 Cycles of Pump per Min.
3-A	Westing-house	11 In.	22,200	160	Full Open	Raise from 75 to 85	2	13/64 In.	1/8 In.	Raise Air Pressure from 75 to 85 Lbs. in 2 Min. against Leakage through Diaphragm
1-B	Westing-house	9½ In.	22,200	160	Full Open	At beginning Atmospheric at close 150	5	No Waste		At end of 5 Minutes Reservoir Pressure to be not less than 150 Lbs.
2-B	Westing-house	9½ In.	22,200	160	Partly Open to give Speed of 52 Cycles per Min.	Maintained Constant at 100 Lbs.	60	1/8 In.	1/8 In.	Maintain Reservoir Pressure at 100 Lbs. for 60 minutes, at 52 Cycles of Pump per Min.
3-B	Westing-house	9½ In.	22,200	160	Full Open	Raise from 100 to 120	5	1/8 In.	1/8 In.	Follow Test 2-B and raise Air Pressure from 100 to 120 Lbs. in 5 Min. against Leakage through Diaphragm.
1-C	Westing-house	8 In.	22,200	160	Full Open	At beginning Atmospheric at close 150	5	No Waste		At end of 5 Minutes Reservoir Pressure to be not less than 150 Lbs.
2-C	Westing-house	8 In.	22,200	160	Partly Open to give Speed of 65 Cycles per Min.	Maintained Constant at 100 Lbs.	60	3/32 In.	1/8 In.	Maintain Reservoir Pressure at 100 Lbs. for 60 minutes, at 65 Cycles of Pump per Min.
3-C	Westing-house	8 In.	22,200	160	Full Open	Raise from 100 to 130	2	3/32 In.	1/8 In.	Raise Air Pressure from 100 to 130 Lbs. in 2 Min. against Leakage through Diaphragm
1-D	New York	No. 5	22,200	160	Full Open	At beginning Atmospheric at close 150	2	No Waste		At end of 2 Minutes Reservoir Pressure to be not less than 150 Lbs.
2-D	New York	No. 5	22,200	160	Partly Open to give Speed of 38 Cycles per Min.	Maintained Constant at 70 Lbs.	60	13/64 In.	1/8 In.	Maintain Reservoir Pressure at 70 Lbs. for 60 minutes, at 38 Cycles of Pump per Min.
3-D	New York	No. 5	22,200	160	Full Open	Raise from 70 to 80	10 Sec.	13/64 In.	1/8 In.	Raise Air Pressure from 70 to 80 Lbs. in 10 Sec. against Leakage through Diaphragm
1-E	New York	No. 2	22,200	160	Full Open	At beginning Atmospheric at close 140	3 Min. 10 Sec.	No Waste		At end of 3 Min. 10 Sec. Reservoir Pressure to be not less than 140 Lbs.
2-E	New York	No. 2	22,200	160	Partly Open to give Speed of 52 Cycles per Min.	Maintained Constant at 70 Lbs.	60	1/8 In.	1/8 In.	Maintain Reservoir Pressure at 70 Lbs. for 60 minutes, at 52 Cycles of Pump per Min.
3-E	New York	No. 2	22,200	160	Full Open	Raise from 70 to 80	1	1/8 In.	1/8 In.	Raise Air Pressure from 70 to 80 Lbs. in 1 Min. against Leakage through Diaphragm

TESTING AIR PUMPS AFTER GENERAL REPAIRS.

NEW YORK CENTRAL LINES.

It is just as important, and possibly more so, to test air pumps after they have been given general repairs as it is to test them after they are first built. Realizing this, the New York Central Lines have, after very careful study and investigation, drawn up a schedule of tests, as shown on the accompanying diagram. Not only are the pumps to be tested after they have received repairs, but it is expected that they will be regularly tested at intervals of six months while in service. The pressure of 160 pounds, required in order to test the pumps under conditions somewhat approximating those met in actual service, has made it necessary to install special boilers at several of the shops. We are indebted for information to Mr. F. M. Whyte, general mechanical engineer of the New York Central Lines.

STEEL VS. WOODEN TIES.—The life of wood white oak ties under heavy traffic ranges from four years on sharp curves to eight or ten years on tangents. There is a wide difference in the durability of timber, even when it is the same kind taken from the same pack of woods. It is beyond the ability of inspector or trackman to select ties that will give the same duration of service. The tie begins to deteriorate from the time it is put in place, the rate of deterioration increasing until it becomes necessary to remove the tie. There is no track work that compensates fully for this deterioration, so you cannot maintain a condition equal to an all new tie track. The steel tie maintains its section, and the bed under the tie does not have to be disturbed on account of tie becoming soft, nor on account of the effective thickness of the tie becoming less, due to rail or tie plate bedding into the tie. The steel tie, up to failure, retains the same dimensions and efficiency, reducing the work required for surfacing and lining, and it is possible throughout the life of the tie to maintain track of the same excellence as with all new ties. Up to the present time we have only had one broken rail on steel ties, and the report attributes this break to a flaw in the rail. We have not used steel ties long enough to determine their life under our conditions, but an examination of a broken tie, after six years' service, does not indicate that rusting under ordinary conditions should cause any anxiety. I somewhere read a statement that Mr. Post, chief engineer of the Netherland State Railroad, found that ties weighing 125 lbs., laid in sand and gravel ballast, had decreased 8¾ lbs. in 35 years, but were still good for 20 years' service.—*Mr. H. T. Porter, before Railway Club of Pittsburgh.*

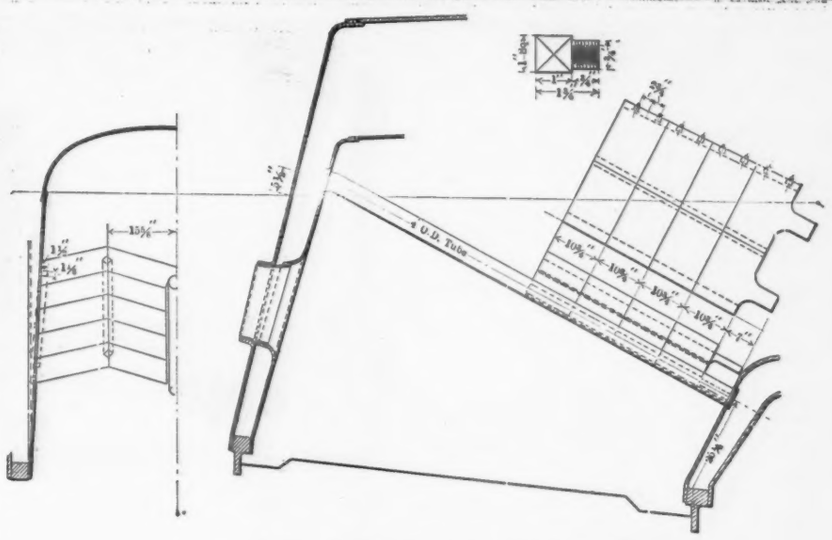
RAILROAD Y. M. C. A.—Sixteen new railroad association buildings have been opened and ten other new associations have been organized, two of them among street railway men, making a total of 225. The membership is over 81,000 and there are now 149 buildings owned and occupied having a total valuation of $2,601,350. In addition, sixteen other buildings are now being constructed at a cost of $538,000, and these when completed will make 165 buildings with a total valuation of $3,139,350. The international railroad secretaries are now eleven in number, eight devoting their entire time and three part time to this department. Two of these, J. M. Dudley, with headquarters at Montreal, and Richard C. Morse, Jr., for educational work on the Gould lines, have been added during the past year. Mr. Moore has been assigned to the New York Central lines. F. B. Shipp, who has, for several years past, been in charge of the work in the southwest, with headquarters at St. Louis, has been transferred to the New York office with a relation to the general work; E. L. Hamilton has been assigned to the territory previously looked after by Mr. Shipp. The contract has been let and ground broken for the new Gould Memorial Building for railroad men at St. Louis, Mo. This building will exceed in cost $200,000.

TECHNICAL MEN IN THE MOTIVE POWER DEPARTMENT.—While a collegiate technical education is undoubtedly an advantage to those who will diligently apply themselves and fully embrace the opportunity offered by the information and knowledge gained in the use of books and instruments, it is not a necessity, and many college-bred men fail, because of their indisposition to go through the probationary period of practical mechanics and thereby learn how to secure the respect of, and to supervise men, and convey information in a manner that will produce results, where the more practical and industrious man will succeed.—*J. E. Muhlfeld, in The Railroad Gazette.*

FIRE BRICK ARCH.

NORTHERN PACIFIC RAILWAY.

A brick arch for wide firebox locomotives, which is supported by a single arch tube, is in use on a large number of locomotives on the Northern Pacific Railway and was applied to the large order recently built by the American Locomotive Company, which were illustrated in our October issue, page 392. The arch was designed by Mr. David Van Alstyne, former superintendent of motive power, and the illustration shows the one as applied to a Pacific type locomotive with a combustion chamber. It will be seen that the bricks arch on either side of the center, being supported by a 4-in. tube in the middle of the box and by square-headed studs, of which there are two to each brick, on the side sheets. A space of 7 ins. is left between the arch and the firebox throat sheet, and the complete arch consists of four rows of brick, each 10¾ ins. wide, making it extend 50 ins. diagonally upward from the sheet.



IRE BRICK ARCH, NORTHERN PACIFIC RAILWAY.

THE BEST METHOD OF SETTING FLUES.

BY G. G. NICOL.*

I have tried many different ways of setting flues in locomotive boilers, and the best method I have found, covering all classes of engines, is as follows:

Carefully inspect back flue sheet and see that all scale and sediment is removed from the inside of both flue sheet and flue holes and that all flue holes are perfectly round. Care should be taken to have the sharp corners removed from inside and outside of flue holes, leaving a good fillet, so that no damage can be done to the flue from sharp corners. Then insert copper ferrules in flue holes and expand with a sectional expander, leaving it flush with fire side of flue sheet. Copper ferrules should be a neat fit. I do not believe in stretching coppers, but if this is necessary they should be reannealed, as hammering copper hardens it and reduces its expansion. It should be left as soft as possible. Swedge the flues to a neat fit and remove all scale from the end of the flues, then apply them, leaving 3/16 in. outside of the sheet for bead, or 1½ the thickness of the flue. This would give you, with a No. 11 gauge flue, 3/16 of an inch, which I think is plenty for any bead. After flues have all been clinched, mandrel them out to copper, so as to admit sectional expander, then drive expander once into each flue, fastening them to the proper length for head. After flues have been fastened in this manner, turn them over with a ball-face hammer, or a suitable tool to fit the pneumatic hammer. Then roll all the flues, commencing at the two top corners, next roll the center flues and then the bottom ones. Then prosser them in the same order as in rolling, turning the sectional expander twice in each flue. By so doing, I think, the expansion is distributed all over the sheet. Finish flues by beading with the standard tool.

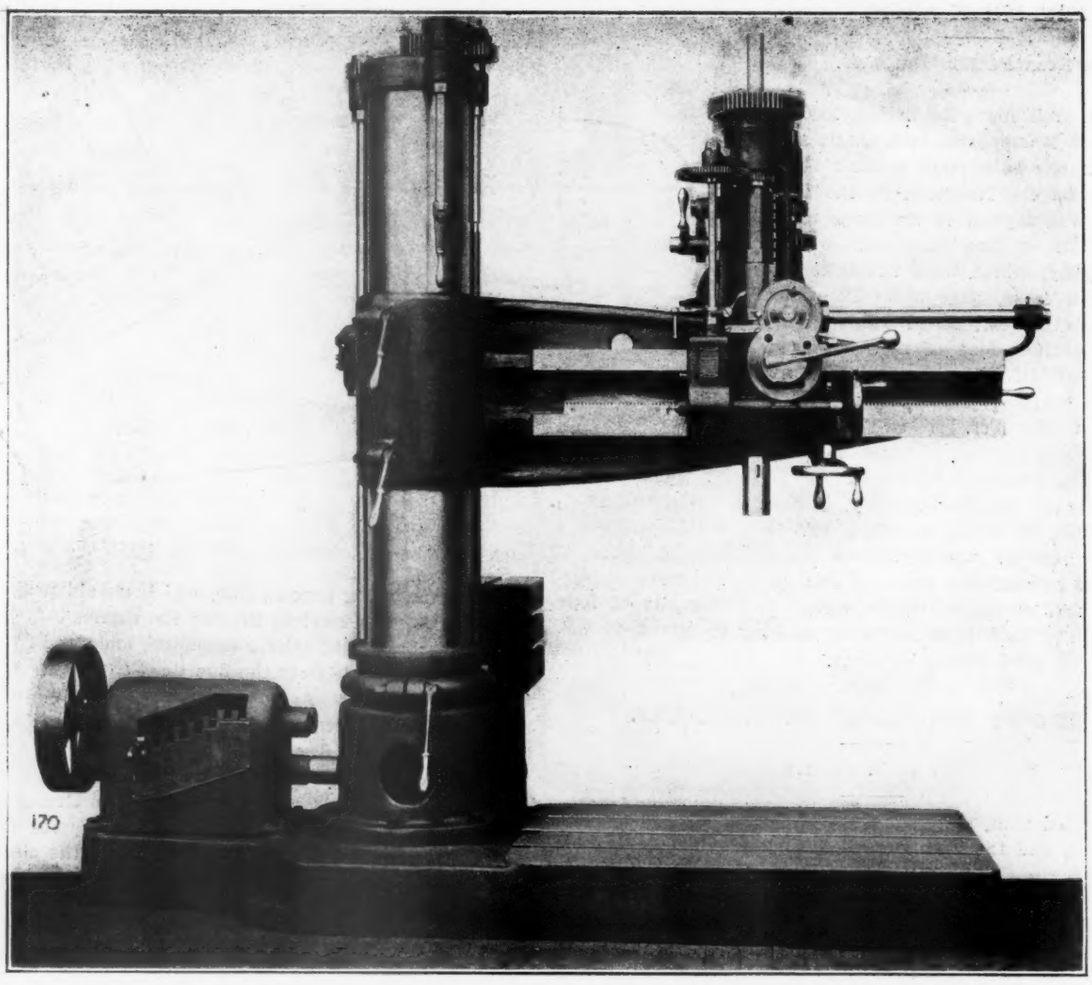
The reason for rolling the flues before the sectional expander is used is because when they are rolled tightly back against the flue sheet the expander only has to do its proper share of the work, putting the shoulder on the flue inside the flue sheet. Rolling the flues after they are expanded shoves the shoulder away from the sheet and takes out most of the shoulder that the expander has made.

I find that heavy copper ferrules give better results than light ones, and would recommend them to be not lighter than 40 lbs., because the heavier the copper, the greater the expansion. I also recommend a long ferrule, which should project through the flue sheet at least ½ in., for the reason that heavy scale or sediment will not adhere to copper, and the further we can keep mud and scale from the flue sheet the longer we can keep flues from leaking. As soon as the water spaces next to the back flue sheet become clogged with scale your cooling capacity is cut out and the flues begin to leak.

*Foreman-boilermaker, C., R. I. & P. R. R. From a paper before the Master Steam Boiler Makers' Association.

ELECTRICAL CUTTING OF STEEL BEAMS AND GIRDERS.—The fire at San Francisco, Cal., following the earthquake of April 18, left some difficult problems to be solved in the clearing away of debris for new buildings. One of the most serious of these is the removing of the tangled mass of structural steel. It occurred to R. E. Frickey that the electric arc might be employed here to advantage, and he carried out at the University of California some experiments to determine the possibilities of this use of the arc. As the result of extensive experiments, described by the San Francisco *Journal of Electricity, Power and Gas*, an electrode has been evolved which has proved successful. By means of this electrode a 15-in. beam was cut in two in 20 minutes. To make a corresponding cut with a hack saw would require several hours. For the best and most economical results a current of about 250 amperes at from 90 to 100 volts is required. In starting, a resistance is employed, but this may be cut out after the arc is formed. One necessary condition for success is the satisfactory protection of the operator. Not only the eyes, but the face and hands must be covered or they will be badly burned. An oilcloth hood having a rectangular opening in front of the eyes is employed, this opening being covered by a mask of oilcloth having a window of specially prepared glass when the are is in operation. Gloves must be worn. Since it is not practical to obtain 110 volts for the work in San Francisco, and it was not advisable to use the 220-volt system, since the neutral is grounded in that city, a portable generating set consisting of a gasoline engine driving a dynamo was arranged.—*Iron Age.*

A NEW NOISELESS GEAR.—The *Iron Age* recently presented a description of a noiseless gear invented by Frank E. Bocorselski, superintendent of the Baush Machine Tool Company, Springfield, Mass. It consists of a cast iron blank, with a sleeve, upon which are fitted three rings, each of a different material: bronze, fiber and steel. These sections are held in place by a key and by three riveted pins, thus forming of the four materials a practically solid gear blank. An exhaustive test of one of these gears has been made in a 42-in. Baush boring mill in mesh with a cast iron gear. The desired noiseless quality commonly accomplished by rawhide and similar gears was demonstrated, and also the wearing quality, which was the inventor's chief purpose.



BICKFORD NEW PLAIN RADIAL DRILL.

HUDSON RIVER TUNNEL OF THE PENNSYLVANIA RAILROAD.—This tunnel, which comprises two single track tubes between Weehawken, N. J., and New York City, reached the end of the first stage toward completion on Tuesday, September 11, at which time the headings met in the north tube. The headings had been advanced continuously from both shores, by shield working, and the point of meeting was near the middle line of the river. An opening through the two shields was made in the afternoon of September 11, and on the following day a celebration party went through. The tunnel is being built by the O'Rourke Engineering Construction Company, the contract being made on May 2, 1904. As the distance between shafts is about 6,500 ft., the average rate of advance has been 8 ft. per day, or 4 ft. per day heading. The two tubes are parallel and on the same level throughout. Its grades are 1.92 per cent. on the New York side and 1.30 per cent. on the New Jersey side. Each tube is circular, 23 ft. in diameter over the shell. The shell is a cast iron (in some places cast steel) sectional tube, which later is to be lined with 2 ft. of concrete. Special segments in the bottom, every 15 ft., make provision for later sinking metal screw piles through the bottom of the tunnel to rock, in order to prevent all possibility of disturbance of the structure from the effects of operating heavy trains at high speed through the tunnel.

THE LARGEST CASTING.—The largest casting ever made in the United States has recently been completed by the Bethlehem Steel Company; it is the frame for a 17½-ft. gap. hydraulic riveter for the Lehigh Valley Railroad shops at Sayre, Pa. It is designed for a maximum pressure of 150 tons per sq. in. A special car was required to transport the machine.—*American Machinist.*

PLAIN RADIAL DRILL.

The plain radial drill shown in the illustration is made in three sizes, 4, 5 and 6 ft. An exceptionally large number of spindle speeds are provided (twenty-four), extending over a wide range, the maximum speed in each case being 13.63 times the minimum. The minimum speed of the 6-ft. drill is adapted to drive a 6-in. pipe tap; that of the 5-ft., a 5-in.; that of the 4-ft., a 4-in. The spindle speeds of the 4-ft. drill range from 22.5 to 306.7 r.p.m., as shown on the following table:

No. of rev. per min. made by spindle.	Diam. of drills for which speeds are suitable.	Actual number of feet per min. at which drilling is done.	Theoretical number of feet per min. at which drilling should be done.
306.7	7/16	35.13	35.35
268.8	½	35.18	35.00
238.5	9/16	35.10	34.65
214.7	⅝	35.13	34.30
195.2	11/16	35.30	33.95
174.1	¾	34.20	33.60
156.1	13/16	33.20	33.25
143.4	⅞	32.85	32.90
121.2	1	31.73	32.20
106.2	1⅛	31.28	31.50
94.2	1¼	30.83	30.80
84.8	1⅜	30.53	30.10
77.1	1½	30.28	29.40
68.8	1⅝	29.27	28.70
62.1	1¾	28.45	28.00
56.6	1⅞	27.78	27.30
48.2	2	25.24	26.60
42.2	2⅛	23.48	25.90
37.5	2¼	22.09	25.20
33.6	2½	21.99	23.80
30.7	2¾	22.10	22.40
27.4	3	21.52	21.00
24.7	3¼	21.03	21.00
22.5	3½	20.63	21.00

It will be seen that suitable speeds are provided for drilling diameters advancing by sixteenths from 7-16 to ⅞ in.; by eights from ⅞ to 2¼ ins., and by quarters from 2¼ to 3½

ins. With the large number of spindle speeds and the small steps it is possible to very nearly approximate the proper speed for any material or size of drill which it is desired to use, and to run the drill as closely as practicable to its limit of endurance.

The different spindle speeds are obtained by two levers, one of which is located on the head and controls the three back gear speeds, and the other projects from the speed box and controls eight speeds. The speed box is similar to the one which was described on page 460 of our December, 1905, issue. The eight speeds are obtained from 12 gears, only three of which are in service at any one time. The mechanism is of the tumbler variety, but the maximum difference in the peripheral speed of the gears is within the limit of 2 to 1, so that the shock which occurs when changing from one speed to another is comparatively slight and has no serious effects.

There are eight feeds ranging in geometrical progression from .007 to .064 per revolution of the spindle; any one of these is instantly available. The tapping mechanism is located on the head, and is controlled by a lever conveniently placed for the operator. The taps may be backed out at any speed with which the machine is provided, regardless of the speed with which they are driven in. A depth gauge is provided, which answers the double purpose of enabling the operator to read all depths from zero, thus doing away with the delay due to scaling or calipering, and it also supplies a convenient means for setting the automatic trip, the graduations showing exactly where the dog should be placed in order to disengage the feed at the desired points. The automatic trip operates at as many different points as there are depths to be drilled at one setting of the work, and in addition it leaves the spindle free, after any intermediate tripping, to be advanced or raised and advanced or traversed its entire length without disturbing the set of the dogs. It also throws out the feed when the spindle reaches the limit of its movement. These machines are made by the Bickford Drill & Tool Company, Cincinnati, Ohio.

EVERETT-McADAM CONTINUOUS ELECTRIC BLUE PRINTING MACHINE.

In practically all modern drafting rooms the old method of blue printing by sunlight has been very largely abandoned in favor of a machine printing by means of electric light. The many advantages of the later method in the matter of convenience, rapidity and expense are so evident that it is not necessary to repeat them.

From its first stage, where the electric light was simply substituted for sun light, the ordinary printing frames and

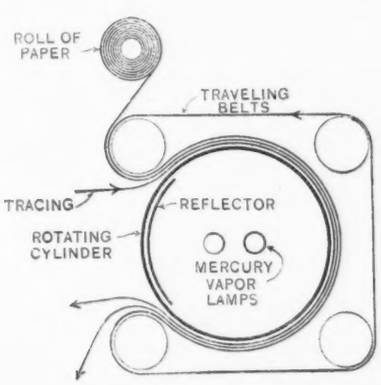
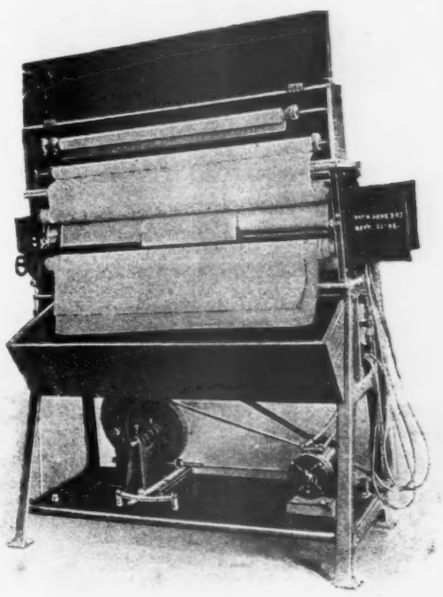


DIAGRAM SHOWING METHOD OF PRINTING.

other apparatus being used, this system of blue printing has passed through several stages of development, each new machine having some important points of advantage over its predecessor, until at present it would seem impossible to improve the efficiency or rapidity of making blue prints over than that obtained with the latest machines.

One of the latest and most modern of these blue printing machines, which has only been on the market for about one year, is that manufactured by the Revolute Machine Company of 523 W. 45th Street, New York, to which the illustrations herewith refer.

This machine consists briefly of a rotating glass cylinder which lies in a series of narrow belts and within which are placed two mercury vapor electric lamps. The roll of paper to be printed is placed in the box at the top of the machine and feeds in continuously between the belts and the cylinder, or if only a few prints of small size are wanted, previously cut sheets of paper may be fed in. The tracings are inserted between the paper and the glass cylinder, and after passing



EVERETT-MC ADAM CONTINUOUS ELECTRIC BLUE-PRINTING MACHINE.

around three-quarters of the circumference of the cylinder they are printed and deposited in the box with the paper located in the front of the machine below the cylinder. The cylinder is driven through gearing by an electric motor and its speed of rotation, and hence the length of time given to the printing can be varied at will.

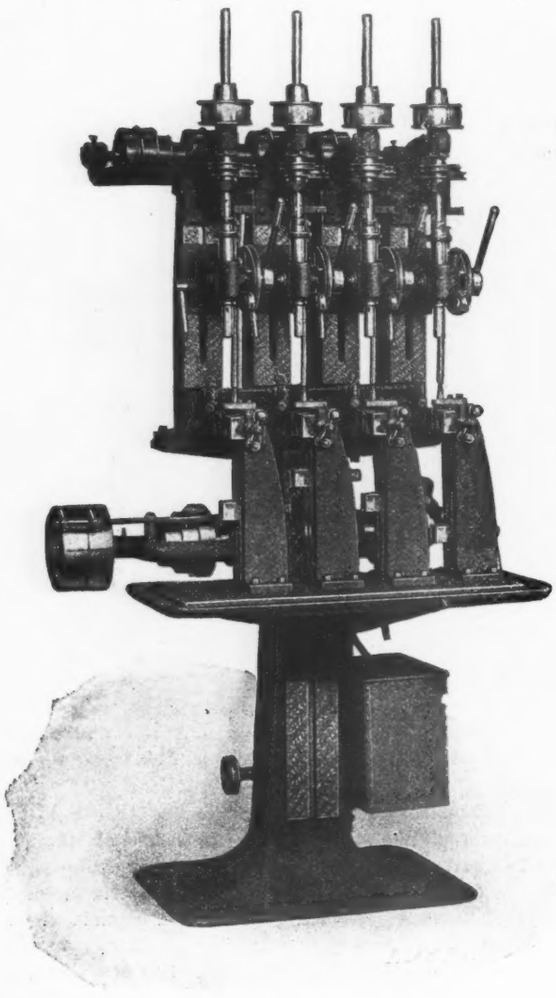
A unique feature of the machine is the use of a number of 1½-in. belts instead of a single broad one. In this way absolutely perfect contact is obtained, which was found to be impossible by the use of a single broad belt. The mercury vapor electric lamps are particularly well adapted for this kind of work, as they give out only chemical rays. The lamps are so situated that the light strikes the paper at right angles at all times, and the machine has a maximum electrical efficiency.

The whole machine is very compact, requiring a space of only 2 x 5 ft., and is entirely self-contained. It is possible to make prints 5 ft. wide and of any length whatever, and the machine is particularly well adapted for making large numbers of small prints on one long sheet of paper, or previously cut sheets which come out in a regular stream and are all of uniform tone. The tracings go in and come out on the same side of the machine, so that the leading edge of the tracing may be fed into the machine again before the trailing edge comes out. This saves time when more than one print is wanted from one tracing, and was very nicely illustrated recently by making 12 prints from one 6-ft. tracing on a single sheet of paper 72 ft. long, without wasting a single inch of paper or a second of time between the prints.

Although this company has been formed but one year there are at present 40 of these machines in daily use which are said to be giving absolutely perfect satisfaction.

FOUR SPINDLE STAY BOLT DRILL.

The four-spindle drill, shown in the illustration, has been especially designed for drilling tell-tale holes in staybolts. It will drill to 3 ins. in depth, using drills up to 5-16 in., and will take staybolts from ¾ to 1¼ ins. in diameter and from 3 to 15 ins. long. The construction of the special chucks, which quickly grip and center the staybolts under each spindle, is shown on the drawing. The lower end of the staybolt



FOUR-SPINDLE STAY-BOLT DRILL.

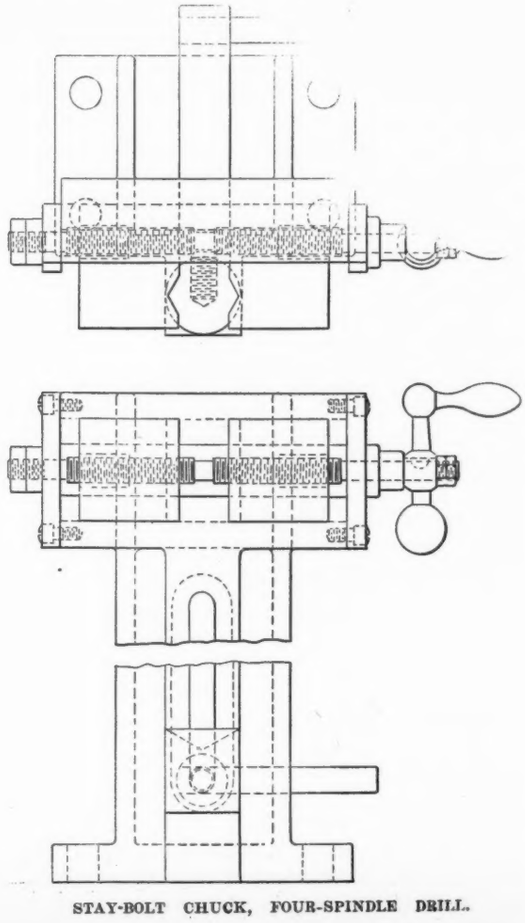
rests in the bell center of the block, which may readily be adjusted to the proper height. The upper end of the bolt is securely gripped by the two jaws. The chucks are set central with each spindle, and a bushing is provided for the drill to run in, insuring its starting central with the piece in the chuck.

Each spindle has three independent speeds and two independent feeds; also an automatic knock-off. Either the feed or speed may be instantly changed for any one spindle without regard to the others. If desired, the staybolt fixtures may easily be removed, and the machine may be used for a variety of sensitive drill work. The spindles are 6½ ins. apart; the distance from the center of the spindle to the face of the upright is 7½ ins.; the maximum distance from the nose of the spindle to the top of the table is 36 ins., while the minimum is 4 ins. The length of the power feed is 3 ins., and the spindle also has a hand feed and quick return. The table is counterbalanced by a weight inside the column.

An oil pump, tank and piping are provided so that oil or soda water may be used in liberal quantities. The machine is made by Foote, Burt & Company of Cleveland, and weighs about 1,200 lbs.

A Mistake Made by Our Technical Schools.—The technical schools have filled a want and have done much good in certain branches of industry, but they assume too much when they undertake to give a young man a course in conservation of forces, statics and dynamics, graphic statics, strength of materials, mechanics, drawing, machine design, mechanical engineering and shop practice, all in the short space of four years. He is given a diploma, signifying he has nothing more to learn and is capable of taking the management of a factory. I had a young man as draftsman who had taken an engineering course in one of the Boston technical schools. He carried a sample of work with him which he had made during his course in shop practice. It consisted of two pieces of cast iron about 2 in. sq. and 1 in. thick. One piece had a groove about ⅜ in. sq. cut across the face, the other piece had a corresponding projection across its face, together forming a tongue and groove. These pieces were accurately fitted together, so that the tongue could slide from end to end, and when reversed fit just as accurately. I asked the young man what tools he had to do the job with. He replied: hammer, chisel, file and scraper. I then asked him how long it had taken him to make the piece. He said that he had spoiled two or three pieces before he got them to fit, and that in all he had probably spent three or four days upon the job. Any modern machine shop could duplicate those pieces with profit for 15 cents or 20 cents apiece. *Time and cost* are the main functions in productive science, and when these essential features are not included in the so-called shop practice the true object of technologly is lost.—*Mr. Thomas Hill, before the Western Society Associated Engineers.*

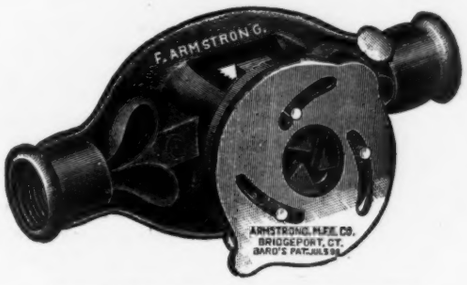
Large Freight Car Orders.—The New York Central Lines have recently placed orders for a total of 17,050 freight cars, and the Pennsylvania Railroad Company has ordered a total of 12,415 freight cars. This makes 29,465 cars to be built for two railroad companies during the next year, most of which will be delivered before August, 1907.



STAY-BOLT CHUCK, FOUR-SPINDLE DRILL.

ADJUSTABLE BUSHINGS FOR DIE STOCKS.

The Bard adjustable bushing for Armstrong die stocks is a time and trouble saving improvement over the ordinary ring bushing. It is made in four sizes, each size taking the same range of pipe as the corresponding number of the stock. One of these bushings is shown attached to the stock in the accompanying illustration. It consists of a strong malleable iron body, having a sleeve fitting into the barrel of the stock. A simple twist of the cam plate brings a set of hardened jaws firmly against the pipe, centering it at the same time. The cam plate is then secured by a thumb-screw, insuring an absolutely accurate and straight thread. When a crooked thread is desired, however, it may be cut as easily as with the old style ring bushings.



ADJUSTABLE BUSHING FOR DIE STOCKS.

This adjustable bushing saves the time of looking up lost and misplaced ring bushings and fitting them to the stock. It is also, of course, much more satisfactory and accurate than the makeshift of wrapping paper or tin around the pipe when the exact size of bushing cannot be found. There is no necessity of carrying a set of bushings in the kit when one of these adjustable bushings has been fitted to the stock. The design is very simple and strong, and when once fitted to the stock there need be no occasion for removing it. These bushings are made by The Armstrong Manufacturing Company, Bridgeport, Conn.

THE FUTURE PRIME MOVER.—It is less than one hundred and fifty years since Watt made the reciprocating steam engine a thing of actual use and fairly began the era of manufactured power. Already the reciprocating steam engine is doomed, except for certain special uses. The development of the transmission of power by electricity has made it possible to use the high efficiency of the steam turbine, and the use of turbo-generators is even now large and spreading fast. But the turbine is only a step. Its successor is already foreshadowed in the gas engine. Side by side with these changes in the type of prime mover advances the art of transmitting and using power by electricity, and so swiftly does the art advance that now the day seems close at hand when we may see short, but important, lines of steam railroad of heavy traffic converted to electric working. The power houses will be equipped with steam turbines or with gas engines. Alternating current will be sent out over long transmission lines and stepped down and used in the car motors without converting. Two great things will be accomplished. Working cost will be reduced and the public will have more frequent, cheaper, and perhaps swifter, service.—*Col. H. G. Prout.*

PERSONALS.

Mr. J. F. Ashworth has been appointed master mechanic of the Tennessee Railroad.

Mr. J. A. McRae has been appointed mechanical engineer of the Michigan Central R. R.

Mr. Chas. Zeity has been appointed general foreman of the Colorado City shops of the Colorado Midland Ry.

Mr. W. J. Haynen, master mechanic of the Detroit, Toledo & Ironton Ry. at Springfield, O., has resigned.

Mr. F. C. Keim has been appointed master mechanic of the Sierra Ry., with headquarters at Jamestown, Cal.

Mr. S. C. Smith has been appointed general foreman of the Cleveland, Cincinnati & St. Louis Ry. at Delaware, O.

Mr. John W. Harris has been appointed road foreman of engines of the Philadelphia & Reading Ry. at Tamaqua.

Mr. J. W. Sanford, master mechanic of the Pennsylvania R. R. at Meadows, N. J., has been retired on a pension.

Mr. L. L. Young, traveling engineer, has been appointed acting master mechanic of the Detroit, Toledo & Ironton Ry. at Springfield, O.

Mr. W. L. Calvert has been appointed master mechanic of the Missouri Pacific Ry. at McGehee, Ark., succeeding Mr. R. G. Long, resigned.

Mr. M. S. Curley has resigned as superintendent of motive power on the Sierra Railway of California, and that position has been abolished.

Mr. Frank Malone has been appointed general foreman of the Oregon Short Line at Pocatello, Idaho, in place of Mr. L. A. Richardson, resigned.

Mr. C. M. Stuart has been appointed to succeed Mr. Allen as master mechanic of the Shamokin division, of the Philadelphia & Reading Ry.

Mr. W. E. Farrell has been appointed general foreman of roundhouse and shops of the Cleveland, Cincinnati & St. Louis Ry. at Columbus, O.

Mr. G. E. Parks, mechanical engineer of the Michigan Central R. R., has been promoted to the position of master mechanic at Jackson, Mich.

Mr. L. Pfafflin has been appointed master mechanic of the Indianapolis Union Ry., with office at Indianapolis, Ind., to succeed O. H. Jackson, deceased.

Mr. R. MacKenzie has been appointed divisional car foreman of the Atlantic division of the Canadian Pacific Railway, with headquarters at McAdam.

The office of Mr. T. Paxton, superintendent of motive power of the El Paso & Southwestern Ry., has been moved from Douglas, Ariz., to El Paso, Tex.

Mr. R. Griffith has been appointed master mechanic of the Colorado Midland Ry., with office at Colorado City, Colo., succeeding Mr. W. J. Schlacks, resigned.

Mr. Michael Hassett has been appointed general engine dispatcher of the Western division of the New York Central & Hudson River R. R., at Buffalo, N. Y.

Mr. F. J. Lass has been appointed acting mechanical engineer of the Mexican Central Ry., with office at Aguascalientes, Mex., vice Charles T. Bayless, deceased.

Mr. M. J. Schneider has been appointed superintendent of motive power of the National R. R. of Mexico, with office at Laredo, Tex., succeeding James Farrell.

Mr. F. L. Macfarlane, storekeeper of the Chicago, Burlington & Quincy Ry. at Denver, Colo., has been transferred to Sheridan, Wyo., vice Mr. F. J. Angler, promoted.

Mr. J. H. Tinker has been appointed master mechanic of the Chicago & Eastern Illinois R. R., with headquarters at Danville, Ill., succeeding Mr. W. J. Hoskin.

Mr. C. R. Naylor, assistant chief clerk, motive power department, Atchison, Topeka & Santa Fe Ry., has resigned, and accepted a position with the Symington Co.

Mr. J. H. Drennan, of the Atchison, Topeka & Santa Fe Ry. car department at Wichita, Kansas, has been made joint foreman of the Santa Fe-Frisco car department.

Mr. J. W. Cain, assistant engineer of tests of the Gulf, Colorado & Santa Fe Ry. at Cleburne, Tex., has resigned to accept a position with McCord & Company of Chicago.

Mr. George H. Lickert has been appointed master mechanic of the Colorado division of the Union Pacific R. R. at Pullman, Colo., in place of Mr. George Thompson, resigned.

Mr. W. H. Hudson, general master mechanic of the Southern Ry. at Birmingham, Ala., has been appointed district general master mechanic, with headquarters at Knoxville, Tenn.

Mr. George Thompson has been appointed superintendent of motive power of the Denver, Northwestern & Pacific Ry., with headquarters at Denver, Colo., vice Mr. A Struthers, resigned.

Mr. H. E. Malone, general foreman of roundhouse and shops of the Cleveland, Cincinnati, Chicago & St. Louis Ry. at Columbus, O., has been appointed general foreman of shops at Springfield, O.

Mr. W. C. Whittaker has resigned as general foreman of Colorado City shops of the Colorado Midland Ry., and has been appointed general superintendent of the Hussell Iron Works at Colorado Springs.

Mr. R. L. Kleine has been appointed chief car inspector of the Pennsylvania R. R., and will be attached to the office of the general superintendent of motive power at Altoona, Pa., vice Mr. J. F. Elder, retired.

Mr. L. A. Richardson, general foreman of the Oregon Short Line at Pocatello, Idaho, has been appointed division master mechanic of the Chicago, Rock Island & Pacific Ry. at Trenton, Mo., in place of Mr. A. C. Adams.

Mr. C. F. Roberts, general foreman at Monterey, Mex., has been appointed master mechanic of the San Luis division of the Mexican Central Ry., with office at Cardenas, Mex., succeeding Mr. J. J. Cavanaugh, resigned.

Mr. J. B. Dorsey, formerly master mechanic of the Denver & Rio Grande R. R., at Leadville, Colo., has been appointed master mechanic of the Cincinnati, Hamilton & Dayton Ry., with headquarters at Indianapolis, Ind.

Mr. Earl C. Metzger, recently assistant superintendent of Nelson Morris & Co.'s Car Works, Chicago, has resigned, and has accepted the position of mechanical engineer with the Hicks Locomotive & Car Works, Chicago.

Mr. George S. Allen, master mechanic of the Shamokin division of the Philadelphia & Reading Ry. at Tamaqua, Pa., has retired after a continuous service of 52 years with that road. He has been master mechanic at Tamaqua since March 1, 1871.

Mr. J. A. Baker, formerly master mechanic of the Southern Pacific Ry. at Houston, Tex., has been appointed master mechanic of the Beaumont, Sour Lake & Western Ry., the Colorado, Southern, New Orleans & Pacific Ry. and the Orange & Northwestern Ry., with headquarters at Beaumont, Tex.

Mr. Walter Reid has been appointed acting road foreman of engines of the Los Angeles division of the Atchison, Topeka & Santa Fe Ry. at San Bernardino, Cal., temporarily relieving Mr. J. B. Galivan of that part of his duties which pertain to the position of road foreman of engines.

BOOKS.

Catechism of the Electric Headlight. 94 pages. Vest pocket size. Published by the *Brotherhood of Locomotive Firemen's Magazine*, Indianapolis, Ind. Price, 50 cents.

This little book is a compilation of questions and answers concerning the locomotive electric headlight. These were published in the *Locomotive Firemen's Magazine* during the year 1905, and include 296 questions and answers, which covers the subject even to its most minutest details as far as the operation and repair is concerned. This volume is well adapted in use for examination of firemen for promotion as well as a study for progressive firemen or engineers. It is accompanied by a number of illustrations on a separate sheet.

Cost of Locomotive Operation. By G. R. Henderson. 192 pages. Standard 6 x 9 ins. Cloth. Published by the *Railroad Gazette*, 83 Fulton Street, New York. Price, $2.50.

The cost of operating locomotives represents about one-third of the total working expenses of railroads, or one-fifth of the total revenue, and it is quite true, as is stated in the first chapter of this book, that, "on large systems the total is a vast amount, running into many millions yearly, yet, in spite of this fact, there is little *definite* information regarding the various individual items of expense, when by 'definite' we mean the actual expenditure per unit of work accomplished. It is true that we can divide the total figures of any one account by the engine mileage, train mileage, ton mileage, or any other factor, and obtain a unit cost for the system or division, but this will not differentiate the uphill and level work, or the slow and time freights, nor can we gather any idea of the cost per horse-power developed per hour, nor the effect of grades, speed, loading, etc. We can further make comparisons between the monthly performances of locomotives, in order to determine whether the coal consumption per engine or ton mile is increasing or diminishing, but if it be increasing, it is often difficult to assign a reason for it, although a perfectly logical one may exist. It is on account of these that this work is undertaken, with the hope of clearing up in part, at least, the uncertainties arising from variable physical and traffic conditions and enabling railroad officials to prognosticate and explain some of the seemingly unaccountable increases and decreases in the cost of operation."

The above quotation clearly explains the object of this work, and in order to accomplish it the subject has been divided up into different items, and each item studied separately in all its effects upon the cost of locomotive operation. These are divided into three general heads, viz.: supplies, maintenance and service. Each of these general heads are divided into individual items. Under the heading of supplies the subjects of fuel, water, lubricants, waste, tools and miscellaneous are taken up separately. Under the heading of maintenance—general repairs, running expenses and renewals are considered, and under the heading of service—engineers, firemen, hostling and turning, cleaning fires, wiping, inspecting and firing-up are investigated. In considering each of these separate subjects it is recognized that the effects and cost of each vary very materially in different sections of the country, and the subject is so handled that the results largely eliminate these differences and can be made applicable to practically any railroad in the country.

The second chapter in the book takes up the subject of fuel, which is a most important item in the cost of operating locomotives, and the effect of each condition in operation is carefully treated. Thus we find what effect the quality of the coal has under different circumstances, in which it is illustrated that it is not always the best coal which will give the cheapest operating cost on certain designs of locomotives. The price is also considered, and it is shown that with the proper design of locomotive a cheap coal can often be made to be less expensive per trip or per ton mile than the higher grade and more expensive fuel. The cost of hauling, handling, loss by shrinkage, storage, etc., are each investigated. The effect of firing, running, design and condition of the power, grades, curvature, speed, tonnage, overloading, acceleration, braking, stopping and weather on the coal consumption and cost are each given careful study, and the results are usually put into curve or tabular form, making them convenient for everyday use.

The third chapter takes up the subject of water, considering its quality, the cost of water treated and untreated, pumping, and in it is carefully considered the value of purified water, showing under what conditions it is cheaper to go to a certain expense to obtain pure water.

The other chapters in the book are each handled in the same detailed manner, and the results is a volume which contains an amazing amount of valuable and useful information, which should be known by all railroad officials in any way connected with the maintenance or operating of locomotives. An index is included, which will assist in making the book convenient as a ready reference.

Economics of Railway Construction. By Walter Loring Webb. Published by John Wiley & Sons, 43 East 19th Street, New York. 324 pages, 5½ by 8¼. Cloth. Price, $2.50.

This book puts in a practical and convenient form much matter on railroad economics which will be of value and interest to a constructing or operating engineer. It does not attempt to go deeply into the theoretical subject, but includes practical matter for the use of the student or railroad man. It is divided into three parts, the first of which consists of the financial and legal elements of the problem, containing chapters on railroad statistics, organization, capitalization, valuation of railroad property and estimation of volume of traffic. The second part consists of the operating elements of the problem, and includes chapters on operating expenses, motive power, economics of car construction, track economics, train resistance and momentum grades. The third part discusses the physical elements of the problem, and includes chapters on distance, its effect on operating expenses and receipts, curvature, minor grades, ruling grades, pusher grades and balancing grades for unequal traffic. The book contains much valuable information put in the form of tables, and the subjects are illustrated by means of curves wherever advisable. Each subject head in the book is numbered, and an index is included for ready reference. The matter is all clearly and concisely stated, and as a whole this volume will be found of value to those concerned in any way with the operation of a railroad.

Management of Electrical Machinery. By Francis B. Crocker, E. M., Ph. D., and Schuyler S. Wheeler, D. Sc. Sixth edition. Cloth, 223 pages, 4½ by 6¼ inches. D. Van Nostrand Company, 23 Murray Street, New York. Price, $1.00.

This book was first published 14 years ago under the title of "Practical Management of Dynamos and Motors," and has twice been completely revised, and many additions, which make its contents timely, have been introduced. For those who desire a handy reference book and source of information for daily use in the operation of electrical machinery this book is especially fitted.

In the first few chapters the authors consider the subject of generators and prime movers from the standpoints of construction, installation and operation. The various methods of connecting generators with the sources of driving power and the proper connections for wiring the various types of generators and motors are considered. Practical information is included regarding such subjects as the balancing of armatures and the installing of various safety devices. The next chapters deal with the details of operation, and give methods for making commercial tests and keeping generators and motors in good operating condition. Such details are considered as the heating of field magnets, bearings, noisy operation, increased speeds, variations in voltage, etc. The latter part of the book is devoted to the description of and suggestions for operating and repairing arc lighting machinery. A chapter which includes a set of questions and answers to assist in localizing and remedying operation troubles is included, and the last few chapters take up the maintenance of railway motors.

CATALOGS.

IN WRITING FOR THESE CATALOGS PLEASE MENTION THIS PAPER.

DAYTON PNEUMATIC TOOL CO.—This company is issuing a circular illustrating and drawing attention to some of the most prominent features of the Green Pneumatic Hammers.

CHICAGO PNEUMATIC TOOL COMPANY.—This company is issuing a booklet which includes the names of some of the users of the Franklin air compressor throughout the world, the list being arranged geographically by countries, states, towns and users. It is very extensive and interesting. Although the Franklin plant has been in operation only about three years, during that time it has built and shipped more than 1,000 air compressors, having an aggregated capacity of 500,000 cu. ft. of free air per minute and representing installations of about 8,500 h.p.

GENERATORS.—Bulletin No. 139, which has just been issued by the B. F. Sturtevant Company of Boston, Mass., in its Engineering Series, presents a full line of generating sets driven by direct-connected vertical enclosed engines with forced lubrication. The published list contains 14 sizes, ranging from 3 to 50 k.w. in output; the former driven by a 3½ x 3 engine and the latter by a 12 x 10. All of the engines were especially designed for generator driving.

STEAM TRAPS.—The Joseph Dixon Crucible Company, Jersey City, N. J., publish a very interesting pamphlet on the subject of steam traps. It is an illustrated description of the several varieties, with valuable suggestions by W. H. Wakeman, expert steam engineer and author of well-known books on steam engineering. Some steam users seem to think that a steam trap is only a luxury to be enjoyed by those who have expensive plants in operation and wish to show many extra appliances which might be dispensed with, and not be missed. This is a great mistake, as a trap is valuable according to the cost of fuel that must be burned to make the steam. Certain it is that this pamphlet is well worth most careful reading, for it is instructive as well as interesting.

THE STAYBOLT SUBJECT IN BRIEF.—A pamphlet on this subject is being issued by the Flannery Bolt Company, Pittsburgh, having been prepared by Mr. B. E. D. Stafford, general manager of that company. The subject has been most carefully treated, and is illustrated by interesting sketches and photographs. The points of weakness of the different types of rigid staybolts are pointed out, and the reasons why the Tate flexible staybolt has proved successful are considered. The pamphlet includes much valuable matter about the best material for rigid staybolts and the stresses which a staybolt will stand. The cost is considered carefully both for installing and renewing. This pamphlet contains much valuable information, and will be of interest to all those connected with the maintenance of locomotive boilers.

ELECTRICAL APPARATUS.—The General Electric Company is issuing a number of publications, one of which is entitled "G. E. Specialties," and is put in convenient form for reference, containing over 200 pages, giving illustrations, brief descriptions and tables of sizes and capacities of a wide array of electric specialties. A detachable price list is included within the same covers. Included in this catalog are many different designs of cabinets for 2 or 3-wire mains and as many outlets as desired for both lighting and power; also circuit breakers, switches, lamp specialties, fuses, insulators, etc. The same company is also issuing a catalog on type H General Electric transformers, which illustrates and carefully describes this type of transformer and its operation. These are made in sizes from 600 to 60,000 watts in practically any desirable voltage ratio. A number of bulletins are also being issued covering the following subjects: Cable terminals; parts of arc headlights, giving reference to catalog number and including prices; variable speed direct current motors with commutating poles; switchboard panels; constant current enclosed arc lamps; polyphase induction motors; GE-78 railway motor, and a careful discourse on the subject of feeder regulators.

STURTEVANT HIGH-PRESSURE BLOWERS.—The B. F. Sturtevant Company, Hyde Park, Mass., is issuing Catalog No. 140, descriptive of high-pressure blowers. These blowers are designed for handling air or gas at any pressure below 10 lbs. per sq. in., and occupy a position midway between the large low-pressure volume blowers or fans, which for many years past have been manufactured by this company, and the strictly blowing engine or air compressor. They may be used to advantage in supplying air blasts for foundry cupolas, forge fires, smelting furnaces, hardening, tempering and annealing furnaces, for pneumatic tube systems, for moving granular material and, in fact, for any purpose where the maximum pressure does not exceed the limit of 10 lbs. These blowers, which were illustrated and carefully described in the February issue of the AMERICAN ENGINEER AND RAILROAD JOURNAL, page 76, are manufactured in a variety of sizes and capacities ranging from 5 cu. ft. to over 15,000 cu. ft. per minute. The catalog thoroughly illustrates and describes all the different details of the blower and carefully explains its operation. A chapter is given on the proper method of installation, and another gives the results of tests made in the foundry, which showed that but 2.45 h.p. was required to liquify each ton of iron, the rate of the melting being 6.65 tons per hour. Another chapter is also given on the use of this blower as a gas exhauster, where it has been

very successful. The next chapter illustrates the blower directly driven by either motors, vertical or horizontal engines, which units are manufactured by the B. F. Sturtevant Company. A final chapter is given on the proper method of testing blowers, and tables are included showing the weight of air under different pressures and temperatures and the flow of air through different size orifices.

CONSOLIDATION TYPE FREIGHT LOCOMOTIVES.—A pamphlet just published by the American Locomotive Company describes and illustrates a large number of consolidation locomotives built for various railroads. This pamphlet includes only consolidation locomotives weighing less than 175,000 lbs., and will be followed shortly by a pamphlet illustrating designs of this type weighing more than 175,000 lbs. The pamphlet opens with a description of the 2—8—0 type, giving its distinguishing characteristics and its special advantages for heavy freight service or service on light rails where the wheel load is limited. Then follow four pages of tables giving the principal dimensions of thirty consolidation locomotives, ranging in weights from 66,000 to 175,000 lbs., the tables being arranged in the order of the total weights of the locomotives. The next two pages show drawings of the side elevation and end elevation of a typical design of consolidation locomotive. The rest of the pamphlet is taken up with photographic reproductions of the locomotives given in the tables, with the tabular information concerning the design on the page opposite each photograph. This is the third of the series of pamphlets which is to be issued by the American Locomotive Company, and will include all the standard types of locomotives, and constitute a record of the production of the company. Copies of the pamphlets already issued on the Atlantic, Pacific and Consolidation types may be had upon request.

NOTES.

WILMARTH AND MORMAN CO.—It is announced that Mr. Corneil Ridderhof, at present treasurer and general manager of the Wilmarth and Morman Co., of Grand Rapids, Mich., has sold his interest in that firm, and will on January 1, 1907, resign in order to undertake a new business.

CORRECTION.—The name Kobbe Company, mentioned in our October issue, should have read The Morse Chain Company, who have recently removed their plant from Trumansburg to Ithaca, N. Y.

BRANCH OFFICE IN CANADA.—The Jeffrey Manufacturing Company, Columbus, Ohio, has established a new Canadian branch office in Montreal, Canada, it being located on Lagauchetiere and Cote Streets.

WATER SOFTENERS FOR SOUTH AFRICA.—The Kennicott Water Softener Company has received through its London office an order for seven water softeners for the Eckstein Group of the Rand Mines, Ltd., Johannesburgh, South Africa.

BOYER SPEED RECORDERS.—The Chicago Pneumatic Tool Company has received orders from the Chicago, Burlington & Quincy Railway for 114 Boyer speed recorders, which are to be applied to the new equipment now being received by that road.

STANDARD SCALE & SUPPLY COMPANY.—This company has recently installed for the Pennsylvania Steel Company at Steelton, Pa., two of the largest railroad track scales ever used east of the Mississippi River, both being of 150 tons' capacity and 46 ft. long.

THE CINCINNATI PUNCH & SHEAR COMPANY of Cincinnati are shipping to the Imperial Steel Works, Modji, Japan, a machine for punching six holes in the standard angle splice bars for 100-lb. rails and a shear for shearing the splice bars to proper length. Both machines are to be driven by General Electric 220-volt direct current motors.

THE T. H. SYMINGTON COMPANY.—This company has secured the services of Mr. C. R. Naylor, who for the past 12 years has been in the mechanical department of the Atchison, Topeka & Santa Fe Railroad. Mr. Naylor will make his headquarters in the Western sales office of the Symington Company, Railway Exchange Building, Chicago.

FARLOW DRAFT GEAR.—In noticing the pamphlet entitled "The Bull Dog of Draft Gears" in our last issue the wording was such as to indicate that the draft spring was so injured as not to be capable of immediate use. That was not the case, however, and the whole gear, including the spring, was in condition to have been applied to another car immediately after the wreck.

ELECTRIC CONTROLLER & SUPPLY COMPANY.—This company announces the opening of a Chicago office in the Merchants' Loan & Trust Building, 135 Adams Street, Chicago, which has been placed in charge of Mr. W. N. Connelly, who has had long experience in the electrical field.

HEATING APPARATUS.—Among the recent installations of heating apparatus made by the B. F. Sturtevant Company, Boston, Mass., are found the following railroad shops: The repair shop of the New York Central at West Albany, the roundhouse of the Southern Railway at Greenville, the new erecting shop of the American Locomotive Company at Schenectady and the Haskell & Barker car shop at Michigan City.

PURDUE UNIVERSITY.—This university entered upon its 33d year on September 12th, and at the end of the second week 1,588 students had been enrolled, of which 86 per cent., or 1,379, were registered in the schools of engineering. The facilities of the engineering department have been considerably increased by the addition of new buildings and equipment during the past year, and a number of additions have been made to the instructing staff.

LARGE ELECTRICAL SHIPMENTS.—The Crocker-Wheeler Company, Ampere, N. J., have within the last few weeks, in addition to all smaller shipments, sent out nine carloads of electrical machinery, of which four carloads of motors went to the National Tube Company, two of generators and motors to the Lehigh Portland Cement Company, two of alternating current generators to the Snow Steam Pump Company and one of small motors to San Francisco.

CHICAGO PNEUMATIC TOOL COMPANY.—A largely increased demand for the Franklin air compressors has made it necessary for the Chicago Pneumatic Tool Company to make very substantial additions to the Franklin plant, and in addition to the extensive improvements which have been made in this plant, during the current year, it has now become necessary to add 150 ft. to the machine shop, which will permit an increase in output from 55 to 70 compressors per month.

SMALL VERTICAL HIGH-SPEED ENGINES.—The May issue of the Journal of the Association of Engineering Societies contains an article by Mr. F. R. Still, a member of the Detroit Engineering Society and chief engineer of the American Blower Company, on "Small Vertical High-Speed Engines." This article, which is illustrated, explains the difficulties attending a satisfactory design of small high-speed engines, and explains how they have been overcome and corrected. It contains much interesting and valuable information.

NEW IRON AND STEEL COMPANY.—The Refined Iron & Steel Company, Pittsburgh, announces that their plant is now completed and in operation, and is producing high-grade puddled iron for various uses. A specialty is being made of staybolt iron manufactured by a process controlled by Mr. Stubblebine, who is the manager of the Company. Mr. Stubblebine has previously for 35 years been superintendent of the Bethlehem Rolling Mills, and with his son, who is superintendent of this plant, has had a long experience in the iron business. The equipment in operation consists of seven puddling furnaces, three heating furnaces, a 22-in. puddle train and a 16-in., 12-in. and 9-in. train of rolls. The president of the company is Mr. J. C. DeNoon; the vice-president, Mr. I. N. DeNoon, and the secretary is Mr. Harry F. Gilg.

STANDARD ROLLER BEARING COMPANY.—Mr. S. S. Eveland, vice-president and general manager of the Standard Roller Bearing Company, Philadelphia, has purchased for that company the entire plant of the Pennsylvania Iron Works Company, which joins their present property. By this purchase they have secured five extra buildings and real estate 1,600 x 120 ft., all on the main line of the Pennsylvania Railroad, which makes the total length of their property over one-half mile. In addition to the above, this company is also erecting the largest reinforced concrete building in Philadelphia or vicinity, which will be devoted exclusively to the manufacture of annular ball bearings, automobile axles, etc. Over 1,200 hands are employed at the present time, and this number will eventually be raised to over 3,000 when building and alterations now under way are completed. During the past few months this company has built and equipped a large crucible steel castings plant, and iron and brass foundry and a large drop forging plant. They now have the largest complete plant in the world for the manufacture of automobile axles and ball and roller bearings.